

# NUTS & VOLTS

## MAGAZINE



\$3.50  
VOL. 18 NO. 2  
FEBRUARY 1997

Exploring Electronics And Technology For The Hobbyist And Professional

# Portable GPS Maps Go Inland



North America





# PicStic™

## The New Standard in Component Computers

### TAKE THIS HARDWARE:

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- Real-time clock
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### WHAT ARE PicStics?

PicStics (PS1-PS3) are component-sized BASIC Stamp™ I pin-compatible computers. They are primarily designed to run with PicBasic, but you can also use C or PIC assembly. They have 8 to 10 I/O lines and optional real-time clock or 2-channel, 12-bit ADC. Using a comfortable language like BASIC, program development simply involves typing a program into a PC and downloading the compiled code into PicStic's nonvolatile memory. Programs remain indefinitely, unless changed. PicStic 1 is \$29. PicStic 2 and 3 are \$39.

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| PS4-X   | includes all functions in -P and -Q devices, plus 2-channel, 12-bit DAC   |
| PS4-DEV | Developer package. Includes PicBasic compiler, PicBasic programmer's manual, PicStic4 programmer w/ZIF socket, and power supply.<br>(PicStic1-3 development systems can be upgraded for a nominal charge) |

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- Peltier device is 1.125" square, has copper plate for thermal mounting on CPU
- Unit is new, and much cheaper than the separate parts!
- Perfect for Peltier experiments!

HSC# 16106

\$24.95



## Rock-Bottom Reno!

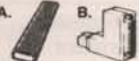
- This is the Last Stock of Media Vision **Reno**:
- Consists of new external Reno CD-ROM drive, docking bay with SCSI2 port, AC Adapter, cables
- Uses NiCad battery pack(s), **not included**
- Double-speed 180mS drive is lightning fast!
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- Available Separately:

\$69.00



## Orchid High-end Video!

Now at reduced prices!

### MPEG + Video Single Card Solution:

- Orchid Technology Kelvin MPEG Video Card
- 64-bit graphics with MPEG Video on one card!
- Full screen 30 Frames/sec MPEG video plus audio
- 1MB version will display up to 800 x 600, 64K colors, or 1024 x 768, 256 colors
- Manual, audio cable & driver software included
- Note, the MPEG portion is not Win95 compatible, but the video portion is. Everything works fine with Windows 3.1
- OEM pack, ninety day HSC warranty

HSC# 16124

\$49.00

### High Resolution Windows Accelerator:

- Orchid Technology Fahrenheit Pro64 Video Card
- 64-bit Hi-Res True Color Windows & CAD Accelerator
- 2MB on-board VRAM, upgradeable to 4MB
- 2MB version will display 16.7million colors at 800 x 600
- Refresh rates up to 120Hz, Green PC compatible
- Manual & driver software included
- Retail boxed RMA's, may show shelf wear.
- Ninety day HSC warranty

HSC# 16172

\$49.00

## Hand-Scanner Special!

- Logitech ScanMan 256-Bit Grayscale hand-scanner
- 100 - 400 dpi resolution, hardware (switch) selectable
- Factory Refurbished, 90-day warranty
- Includes Fototouch image acquiring & editing software, Omnipage OCR software
- Latest Windows 95 drivers included
- Comes with manuals, power supply, 16-bit interface card

HSC#15986

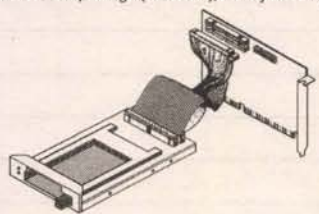
\$34.95

## PCMCIA Card Reader

- IBM Compatible Reader/Writer for PCMCIA Cards
- SwapBox by SCM Microsystems with 16-bit ISA Bus card
- Convenient front access for slots (not in rear of system)
- Fits in 3.5" drive bay, or use included 5.25" bracket
- Dual slot, Type I, II or III, hot swappable
- Perfect for transferring data or hardware from laptops, notebooks or Kodak Cameras to desktop PC's
- Includes driver disk, manuals, cable, internal card, bracket
- New in OEM package (white box), 90-day warranty

HSC#15954

\$79.95



## PCMCIA SCSI Card

- Mediavision PCMCIA SCSI II Card for Laptops
- Use with CD-ROM Drives, WORM Drives, Hard Drives, Scanners, any SCSI I or II device
- Bundled with Corel SCSI (ver. 2.04) software
- Cable, installation software, manual included
- Would make excellent laptop connection to Reno, above
- New in box with software, 90-day warranty

HSC# 15893

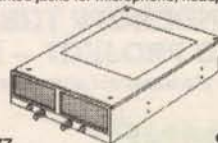
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## Hobby Parts Potpourri!

- Copper Foil Tape - .5" x 18 yd. roll, adhesive is conductive! HSC#16189 \$4.95
- Karaoke-style microphone, good quality, black & gold HSC#16156 \$2.95
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HSC#16277

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- Suncom FX-2000, new in box, unbelievable value!
- Form fitting joysticks work with either hand
- Suction-cup feet anchor them for lightning fast action!
- New in box - 30 day warranty
- Hurry, they are going fast!

HSC#16212 Suncom FX-2000 Joystick

\$3.95

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- Infrared Remote operates your computer from 50 feet
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- Handheld remote is 7" x 2.5" x .5"
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- Roam the room, make eye contact with your audience
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HSC# 15240 IBM Remote Keyboard \$14.95

HSC# 15241 Mac Remote Keyboard \$14.95

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- Includes driver disks, photocopied book
- OEM package (no box), 90-day warranty
- We had these and ran out...New Stock at Lower Price!

HSC#16164

\$39.95

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- 29.5" tall, with room for 21" of vertical instrument height
- 23.25" wide, and 30" front-to-back, textured black finish
- Made by AMCO Engineering
- Units are new in box, strapped to skids, ready for truck shipment (cannot go UPS)
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HSC# 80398

\$149.00



## FaxBoy for paperless FAX!

- High performance fax machine, saves space and paper!
- D2 FAX by Seponix with FaxBoy software uses 3.5" floppy disks rather than paper for input/output
- May be used as back-up to existing fax machine, or as a stand-alone fax (no need to leave computer on-line)
- Units are new in box with software, power supply, manuals
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- View and compose faxes on your computer, use top keypad to program unit and send faxes
- DOS, Windows 3.XX or Windows 95 compatible
- 90-day Warranty



HSC# 80400

\$59.95

## SCSI Drive Case Deal!

- Low-profile case for 5.25" drives
- Perfect for CD-ROM drive
- 9.75" x 2.25" x 1.1" overall size
- 50-pin SCSI daisy-chain connectors
- Internal 50-pin cable, SCSI ID switch
- 30-watt power supply, DC Fan cooled
- New case is attractive grey color, has 90-day warranty



HSC# 16185 Low-Profile 5.25" Drive Case \$29.95

## Tricky Tuned Mag-Switches!

- Ordinary magnetic switches used on doors and windows in security systems can be defeated by secretly placing another magnet next to the switch on the frame, where it doesn't move
- These government-spec. magnetic switches are carefully biased so that they only respond to their matched magnet.
- Box is 4.75" x 2.5" x 1.75", magnet is 4.75" x .5" x 1.75"
- Rugged die-cast box is gasketed, and has tamper switch
- New in box, buy six and save! Retail is over \$25 each!

HSC#16056

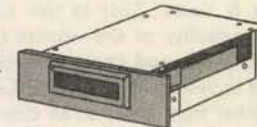
\$9.95 ea., or 6/\$50.00

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- Irwin AccuTrak tape drives -- holds 250 Megabytes
- Brand new in box with 90-day warranty
- "Backup Exec" software for DOS/Windows 3.XX included
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- Made for IBM so you know it's rugged!
- Includes new 250MB unformatted tape (allow approx. 2 hours to format)

HSC#15805

\$39.95



- Irwin Tape Backup Accessories --
- 3.5" Faceplate, Dark Gray HSC# 15808 \$2.95

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(1-800-442-5833)

http://www.halted.com

(408) 732-1573

(916) 338-2545

(707) 792-2277

-or-

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## Visit HSC's Website!

- Pay us a virtual visit on the World Wide Web!
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- Hot off the presses! First one in four years! The wait is over!
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- All orders from January 15 on will have one included

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The closing date for each issue is the 10th of the prior month, e.g., the closing date for the June issue is May 10th. Ad copy to be typeset by Nuts & Volts should be received one week prior to the closing date.

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## EDITORIAL CONTRIBUTIONS

Nuts & Volts Magazine encourages article submissions and queries. Send a SASE for a copy of our writer's guidelines.

All submissions should be on 5-1/4 or 3-1/2 inch diskettes and include hard copy as well. If return of materials is requested, include a SASE with your submission.

Deadlines should be discussed in advance with the editor, but generally all material should be submitted by the 1st of the month for the next month's issue.

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We will not be able to replace missed issues of the magazine due to unreported address changes.

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# reader FeedBack

Dear Nuts & Volts:

I enjoyed your informative article "The Nuts & Volts Solar Workshop" in the Jan. '97 issue. However, in your "Where to Buy" sidebar you left out one of the premier solar suppliers in the country, which is:

## REAL GOODS

555 Leslie St.  
Ukiah, CA 95482-5576  
website: <http://www.realgood.com>  
E-Mail: [realgood@realgoods.com](mailto:realgood@realgoods.com)

Anyone contemplating the purchase of anything solar should check them out.

**August Salemi**  
Atascadero, CA

Dear Nuts & Volts:

I found your January *Nuts & Volts Magazine* and it was very interesting. The lead article about a desktop linear power supply caught my eye as I am interested in just such a thing. But it seems the author, William C. Hendry IV, left out a significant part of his article. It is clear the construction part of it refers to modifying an existing power supply, but what that supply is not given to us. Please tell me what power supply the author had in mind to modify, where it may be purchased, and its cost.

**R. Keith Heinsohn**

Dear Nuts & Volts:

In the Jan. '97 article "A High-Quality Desktop Linear Power Supply for Automotive Electronics," the author begins his project by selecting a "power converter," which has a transformer with carefully selected specifications, as the basis for the project. He also uses the enclosure, power switch, and fuse holder of the "power converter." Nowhere in the article, or any of the table, or the parts list, are we given a source for either the "power converter" or the transformer. Is any additional information available as to the source of the transformer used in this project?

**Dale C. Vawter**

Response:

As several *Nuts & Volts Magazine* readers pointed out, the Source table was not provided for the "High-Quality Desktop Linear Power Supply for Automotive Electronics," article found in the Jan. '97 edition. We sincerely regret the omission.

**Sources:** The power supply used in the article was the Pyramid Gold Series model PS-12K ordered from J.C. Whitney, May 1996 for \$59.95. Since then, we identified a similar \$49.95 unit from Hosfelt Electronics, Inc. pn# 40-160. The LM338K and the voltmeter, pn# LCD Panel Meter is from B G Micro. The 433K heatsink is Newark Electronics pn# 58F334. All other components

such as rectifiers, filters, and potentiometers are from Digi-Key.

**Hosfelt Electronics, Inc.**, 2700 Sunset Blvd., Stuebenville, OH 43952-1158, 1-800-524-6464.

**Newark Electronics**, 1-800-298-3133 for a local distributor.

**B G Micro**, P.O. Box 2802898, Dallas, TX 75228, 1-800-276-2206.

**Digi-Key Corporation**, 701 Brooks Ave. South, Thief River Falls, MN 56701-0677, 1-800-344-4539

**William C. Hendry IV**  
Norfolk, VA

Dear Nuts & Volts:

The answer to Tech Forum Question #12964 Dec. '96 by Darryl Gibson is incorrect.

"... A 12-volt gel-cell has the same charging characteristics as a common auto battery. The internal resistance of the battery will limit the charging current of the cell." This is wrong. The internal resistance of a lead-acid battery will not limit the current unless the battery is large enough compared to the full output of the alternator. Auto batteries regularly boil as they go through 13.8 VDC because all the external regulated and most of the internal regulated alternators turn full on (no current limit) then off at about 14.2 VDC.

The gel-cell battery will be damaged by this slamming to 14.2 VDC. I lived on solar for many years and my deep cycle battery would boil at 1 amp! (as it approached 75% charge). But it would take 15 amps at 50% charge.

Gel-cells need to be discharged at C10 (amphour = 4, discharge must be < .4 amp to get maximum energy). You can discharge them faster, but expect 80% of capacity!

**Thomas Scott**  
via Internet

Dear Nuts & Volts:

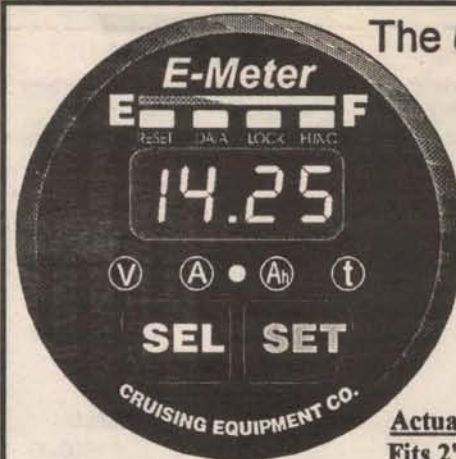
In the Nov. '96 issue, a reader had asked about Powerchute software for an APC UPS. The answer suggested purchasing it from APC for \$70.00 or so. Please notify this reader that, if he has the CD-ROM version of Windows95, this software is available free in the \DRIVERS \UPS \APC directory of that CD.

**Brian Click**

Dear Nuts & Volts:

NTE Electronics now has a 7th edition of their semiconductor catalog, and new versions of their QUICKCross software for DOS and Windows. NTE has a web site (<http://www.ntelinc.com>) where users can get product information, view selector guides, get data sheets, perform online searches (updated every month), locate their nearest NTE distributor, and also download the latest versions of QUICKCross for free!

**Fred Blechman**  
West Hills, CA



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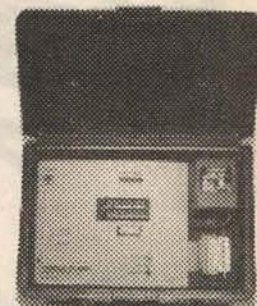
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# Buying Used Test Equipment

by Gerald Roylance

**T**he cover of *Analog Circuit Design: Art, Science, and Personalities* (edited by Jim Williams, Butterworth-Heinemann 1991) shows a workbench with a Tektronix 547 oscilloscope. Although the type 547 is a vacuum tube dinosaur, it still has reasonable performance — better than many new scopes sold today.

Used laboratory test equipment from the 1970s and 1980s is a good buy. For example, a new Tektronix TDS 320 digital scope (100 MHz) goes for \$2,895.00 today. A new GoldStar 40 MHz scope goes for \$580.00. In contrast, a used Tektronix 465 (100 MHz) is less than \$500.00. That's substantially less than the newer Tek scopes, and better performance and quality than the low-end alternatives. Of course, used analog scopes don't have the features of today's digital models.

Although there are good deals out there, buying used equipment is just like buying used cars — you must know what you are buying.

## Where to Buy

Many stores sell used equipment, and the convenience, risk, and price vary accordingly. Buying equipment "as-is" is riskier, but cheaper than buying it with a guarantee. If you have time and like haunting surplus stores and swap meets, then you can buy when a good deal comes along. If you're in a hurry, then checking the want ads and calling dealers are the best bets. Below are the kinds of dealers you will find.

## Used Test Equipment Dealers

Dealers buy equipment from companies who no longer need it. They make sure the equipment works and even calibrate it before they sell. The package includes the equipment, its manuals, and a warranty. The prices are high, but there is little risk, and you don't waste time looking for the equipment you want.

## Surplus Stores

Surplus stores offer equipment at the same prices you see in the classified ads, but you can look the merchandise over and even test it before buying.

The quality of the product varies. Surplus stores usually get the equipment the dealers don't want, so the units either have

problems or aren't in demand. The problems may be minor, and the stuff the dealer didn't want may be just what you need. Unfortunately, the junk and the overpriced units stay around while the bargains disappear quickly.

Occasionally, these stores will have parking lot sales with extraordinary bargains.

## Mail Order

Dealers, surplus stores, and individuals place classified ads in *Nuts & Volts* and other publications. Make sure they offer an inspection period. If you can, pay with a credit card because it gives you some leverage in a dispute. These magazine ads will also tell you the market price.

## Swap Meets

Swap meets are hit or miss, so you may not find what you want. All kinds of sellers will be there. Although some dealers will take booths, most sellers are individuals who collect and sell equipment on the side or individuals who are getting rid of some equipment they own. You can get some good deals from the latter group, but you cannot rely on the selection or the quality.

The early bird gets the worm at these events.

## Auctions

I've only been to a few auctions and, in my opinion, none of them were worth it. There are some silly scams such as the buyer's premium where you pay a lot more than what you bid. The main problem with an auction is all the other people who bid up the price. Well, that's why it's an auction, but a lot of the bidders don't know what they are doing, and they drive the price above wholesale (roughly 60% of the retail market price).

Some frenzied bidders will even drive the price for used equipment above the retail price for new equipment. Bidding for basic equipment such as scopes is fierce. The lucky bidders are the ones going after esoteric equipment such as electron microscopes that nobody else wants.

The best bargains have been the palettes, but the bidding can be frightening. A couple times I've gone after a palette, but so have others, and they wanted it more than I.

Besides, I don't have the space to store a palette full of stuff, and what would I really do with four workstations?

## Price

Supply and demand determine the market price for a typical piece of equipment, but the condition of the individual piece of equipment is also important. If you are going after a major piece of equipment, you better do your homework and find out the market prices. Make sure you compare prices for the same configuration; extras such as manuals and probes make a big difference. Watch out for subtle differences between models: a DC503 counter goes for about \$125.00, but a DC503A goes for \$200.00.

Catalogs are the best source of information because they have specifications and prices. Nothing on a Tek 7A18 will tell you its

about problems with the B trigger.

Appearance shows how the equipment has been treated. If it has been sitting out in the rain, it may still work, but it hasn't gotten the same care as a unit that's been inside. Broken knobs, missing bezels, and scratched gratings don't render the equipment useless, but you should get a price break. Bent shafts mean repairs are required and there should be a steep discount. Don't forget labor. Even if you do the work, the price should drop about \$50.00 per repair hour.

Look for missing parts. People will try to sell equipment at the market price even though it is missing critical parts. Look for missing cards and dangling wires that go nowhere. Common sense

### Tektronix 7904 500 MHz oscilloscope with plug-ins

Model	Description	Tech-Systems with manuals	What I paid
7904	500 MHz mainframe	\$600.00	
7A26	200 MHz vertical	\$200.00	
7A26	200 MHz vertical	\$200.00	
7B85	400 MHz timebase	\$375.00	
7B80 Opt. 2	400 MHz timebase	\$325.00	
Total or package price		\$1,700.00	\$395.00 + \$175.00 for manuals

### Tek 7D15 225 MHz Universal Counter plug-in

Model	Description	Tech-Systems	What I paid
7D15	225 MHz counter	\$250.00	\$100.00
7D15 manual		Included	\$20.00

bandwidth, and bandwidth determines the value of a plug-in. The manufacturer's catalog is best for the details about the equipment, but a catalog of used test equipment will list the salient features and give you a better idea of the current market price. The retail price 10 years ago doesn't matter much. Looking at ads will tell the current price range, but most ads don't give the specs. I have a used test equipment catalog to which I add price information.

The market price is for a typical unit, and if a unit isn't typical, then its prices should be different. The central concern is: Does the unit work? If you have a chance to test it or to return it if it doesn't work, then the purchase doesn't carry much risk. If you cannot test it and cannot return it, then it should cost less than a unit you can test or return. A guarantee is worth at least 20 percent of the purchase price.

Always ask the seller if the equipment works — it doesn't cost anything to ask. At worst, the seller will lie, but he might tell you

helps. If the cover is loose or missing a few screws, then be suspicious. Technicians remove the cover when there is a problem, and if the problem isn't fixed right away, then the cover and the screws sit around and get lost. If the calibration seals are intact, then the unit should have all its parts. If the seals are broken, then somebody repaired the unit.

Property stickers offer clues about an instrument's life. Equipment from a rental agency usually has a hard life.

## Manuals

There is a healthy market in used manuals, so manuals are expensive. A company will often sell their surplus hardware to one dealer and their manuals to another.

I always get a service manual. Operator manuals usually don't say much, so I don't bother. The service manual tells how to fix the unit, how to order replacement parts (such as cracked knobs), and how to calibrate the instrument. Even if the equipment



### Tek 465B Scopes

Model	Description	Tech-Systems	Surplus Store	What I paid
465B	100 MHz Scope		\$400.00	\$150.00
465B manual		Included	No	\$70.00
Probes		Included	No	\$80.00
Package		\$650.00		\$300.00

### Tek FG502 Function Generator

Model	Description	Tech-Systems	What I paid
FG502	11 MHz function generator	\$350.00	\$40.00 + \$20.00 for parts
FG502 Manual		Included	\$20.00
TM504	Power Module	\$375.00	\$100.00 + \$10.00 for parts
TM504 Manual	Included	\$20.00	

works now, the service manual is an insurance policy for later problems.

Manuals Plus (801-882-7188) and Tech-Systems (800-435-1516) sell manuals.

### Bargaining

Usually a price (even a sticker price) is flexible, so you should bargain. When there are no sticker prices — such as a parking lot sale — the seller expects to bargain, so their first offers will be a little high. Equipment on consignment usually has a firm price.

Before you start bargaining, you should determine your price range. Have a minimum and a maximum price. The maximum price is the most you will pay, and if you cannot get it for that price, you will walk away. If you bargain without a maximum price, then you won't know where to stop, and the seller will control the show. With a maximum price, you have clear limits and you won't have to think on your feet. A walk-away price also minimizes buyer's remorse. If you get it for your maximum, then you still got a good deal.

The minimum price represents what you consider to be a real bargain. That's a bargain — not a steal. The minimum can be your initial offer or a counter offer.

Haggling over a few percent is silly, so there should be a healthy range between your minimum and maximum prices. There aren't any hard and fast rules, but the minimum price could be about 60% of your maximum price.

Think about how your offers will be received. If your offer is too low, then the seller won't bother to bargain. If his asking price is too high (say a factor of two over your maximum), then a counter offer is probably hopeless. Striking a deal will make both sides unhappy because the buyer pays

too much and the seller doesn't get enough. If the offers aren't close, don't bother.

You can still bargain when the prices are far apart if you have some good bargaining chips. A printed ad or a serious defect can convince the seller that his merchandise is overpriced. If your price is reasonable, then you may convince the seller to deal.

Tell the seller why you are interested in his equipment, what you want to measure, or that you don't have an immediate need for the equipment. It doesn't hurt to be friendly — and you might get a better deal.

### Example Purchases

Following are some of my purchases and some reasoning behind them. I've included repairs, probes, and manuals because they are often hidden portions of the price. Although I'd like to say I bought a scope for \$150.00, that isn't exactly true because I had to spend another \$150.00 for the probes and the manual. Some purchases become disasters when you include the labor and parts costs.

Buying the Tek 7904 for \$395.00 was a fabulous deal. I bought the equipment at a surplus store where I could power up

7B53 (100 MHz horizontal timebase), so knowing the models gave a better combination. I could also select units that were in better shape.

I wanted a scope that worked, but I could live with some minor problems and was willing to do repairs. The scope's internal triggering did not work, but at the store I could see that two CA3024 integrated circuits were missing (a

dead scope next to it had the ICs). External triggering worked, so I guessed that replacing those ICs would make the scope trigger work. The calibrator did not work because a set screw had fallen out. The readout circuits were flaky, something that cleaning the V/division switches with isopropanol mostly fixed.

Do not buy a scope with a bad tube because it will cost a fortune to fix. The quick check for the tube is to make sure the trace is bright at a modest intensity setting and that the focus control works.

This scope had no trouble with the tube or the power supplies. Next, check that all the controls work — especially the input attenuators because they get a lot of use and usually go first. One 7A26 had a flaky 2X attenuator I missed when testing it at the store.

### Manuals

7904 manual	\$105.00
7A26 manual	\$25.00
7B80 manual	\$35.00
7B85 manual	\$15.00

Manuals are expensive, and these manuals cost \$175.00 — almost half of the cost of the scope. I ordered these manuals

### Scope Probes

A scope isn't worth much without probes. Used scope probes are not a bargain, so buy them. Probes are delicate because they are high impedance, low capacitance, small, and flexible. Even Tektronix probes eventually break or become intermittent.

Two hundred megahertz probes are not cheap. A Tektronix P6106A costs \$215.00, and the P6111B is \$140.00. Stack sells some 350 MHz probes for \$100.00. Pomona sells a 200 MHz 6102 for \$50.00; they looked like a good deal, so I got two.

### Summary

All told, my scope cost about \$700.00 plus about four hours of repair time. The scale readout is a bit flaky, but the likely suspect is a trim pot on the readout board. I'm happy with it, and it beats the hell out of my 5 MHz scope.

### Tek 7A24 plug-in — 350 MHz, 50 ohm input

I bought this plug-in for \$200.00 from a surplus dealer. The manual cost another \$45.00 from Manuals Plus. For comparison, the want-ad prices without a manual were about \$250.00; Tech-Systems wants \$350.00 (I don't know if the manual is included); Test Lab Company (with manual) is \$800.00.

This purchase is not a bargain, but it is about the street price. The plug-in was perfect — and it was the later model of 7A24 (serial number > B113000).

Although the 7904 is a 500 MHz mainframe, the 7A26 vertical amplifiers limit the system bandwidth to 200 MHz. Other plug-ins offer better bandwidth, and the choices were a single channel 7A19 (500 MHz, about \$150.00)

or a dual channel 7A24 (350 MHz, about \$250.00). Both amplifiers have 50-ohm input impedances. The 7A19 offers greater bandwidth, but getting up to 500 MHz wasn't that important, so I went with the dual channel 7A24.

After this purchase, I had a 350 MHz scope with manuals and probes whose total cost was about \$1,000.00.

The Tek 7D15 was at a surplus store, and it tested okay in the store. Although the

counter's performance is only 225 MHz (1.3 GHz is typical for today's counters), it is a universal counter at a good price.

I bought two Tek 465B scopes at a parking lot sale. Both were perfect, and their calibration stick-

### Tek TM503 power module, DC503A 100 MHz counter, DM501A true RMS multimeter

Model	Description	What I paid
DC503A	125 MHz Counter	\$450.00 Western Test
DM501A	Digital Multimeter	\$400.00 Test Lab Co
TM503	Power Module	\$325.00 Tech-Systems
Package		\$125.00 R&S Surplus
Manuals		\$100.00
Parts		\$50.00
		\$50.00 + 8 hours

### Tek PS503A Triple output supply

Model	Description	Tech-Systems	Test Lab Co.	What I paid
PS503A	Triple Output Power Supply	\$275.00	\$495.00	\$200.00
PS503A Manual		Included	Included	\$25.00

and test the scope. They gave me a choice of plug-ins, so knowing what I was buying was important.

The scope would cost me the same with some crummy 7A18s (75 MHz vertical amplifiers) and

from Manuals Plus. Tektronix sells microfiche of old manuals (the 7904 fiche is \$15.00), but I don't have a fiche reader and preferred paper.

The scope and manuals brought the cost to about \$600.00.



ers were less than 18 months old. The seller wanted \$200.00 each, but he accepted \$300.00 for both.

I bought the manuals from Tech-Systems for \$70.00 each; Manuals Plus wanted \$110.00 each.

I wasn't interested in the Tek TM500 series modular instrument line, but then I stumbled across a cheap 1.3 GHz counter, some amplifiers, and finally a function generator at a parking lot sale. The function generator made me decide to buy, but by then the counter and the amplifiers were gone.

I'm not too fond of function generators because they have high distortion and poor stability. The sine wave output uses a piecewise linear shaping network, and a multivibrator instead of a linear oscillator determines the frequency. But a Tek FG502 function generator goes to 11 MHz, and it was only \$40.00.

Why \$40.00? A knob was broken, the pilot light burned out, and some internal parts were loose. All except the low-frequency ranges worked. The unit had vanilla parts and looked easy to fix. A half hour of work soldered the low-frequency range capacitor back in place and determined that the bulb was burned out. A replacement knob and lamp from Tektronix cost \$20.00.

Unfortunately, the FG502 is a plug-in that needs a power module, so I bought a TM504 (four slots) for \$100.00. The power module worked fine, but it was missing a bail and a module guide. Those parts cost \$10.00 from Tektronix.

The whole package cost \$210.00. A consumer brand function generator will cost twice that much (but it will have a sweep generator to go with it). On the plus side, I now had three empty slots in a TM504 to fill with other bargains.

I didn't need another universal counter, multimeter, or a power module, but they were in a package at a surplus store. There was no price and no consignment sticker. Powering the three up showed that the power module and the DVM worked. The DVM had an ancient, but undisturbed calibration sticker — nobody had ever felt a need to take it apart. The counter, however, was catatonic. The digit display didn't even light. Closer inspection showed that someone had tried to repair the counter, but had given up. A 7400 was tack soldered to the board. The counter had an ancient LSI chip, so repair might be impossible. Furthermore, it was only a 125 MHz counter. The counter was

junk.

The seller wanted \$175.00 for the package — a reasonable price for the power module and the DVM. After I showed him the abandoned repair work on the counter, he gave me all three for \$100.00 — a great price for the working units. The seller didn't understand that the power module alone was worth \$100.00.

The counter really was toast, but fixing it became a matter of foolish pride. A high-voltage, high-power AC input (a transmitter?) had shorted the protection diodes to the +5 volt rail, and then rail overvoltage destroyed almost all the ICs on the board. It was the worst failure I'd ever seen.

Tektronix still sold the counter chip for \$20.00, so I pulled and replaced all the chips. The input dual MOSFET for one channel was dead, but Tektronix wanted \$70.00 for the replacement parts; I used two discrete MOSFETs instead.

The manual for the Tek TM503 cost \$20.00, and the manual for the DC503A was \$30.00, but I couldn't find a manual for the DM501A. The replacement parts for the DC503A cost about \$50.00 and took about eight hours of work, so the counter cost about \$450.00 in parts and labor even though I got it for free. I should have chucked the counter when I learned the extent of the damage.

The PS503A has two variable supplies and one fixed five-volt supply, and it works with my other TM500 equipment. The Tektronix power supplies in this series don't have meters like the HP and Kepco supplies. Instead, they rely on calibrated potentiometers and the intensity of some incandescent lamps.

The classified ads showed the price going from \$175.00 to \$250.00. A local surplus store was asking \$250.00, but when I showed them the ads, we agreed on \$200.00. The unit has a flaky fine adjustment pot.

### Kay 432D Step Attenuator

This 101 dB step attenuator cost \$25.00, and I'd wanted one for a long time. Watch out when buying equipment because it is easy to miss some important details. There were several attenuators that looked similar, but they were oddball 93 ohm models. Only one unit in the batch was 50 ohm, and one of its BNC connectors was bent. The back end of a drill bit and some clamps put the BNC back into round, so the repair was simple. NV

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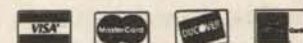


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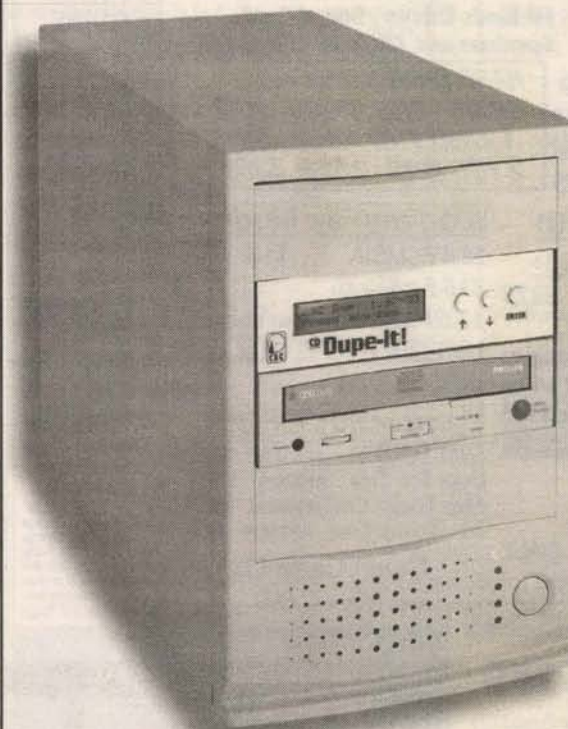
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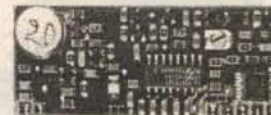


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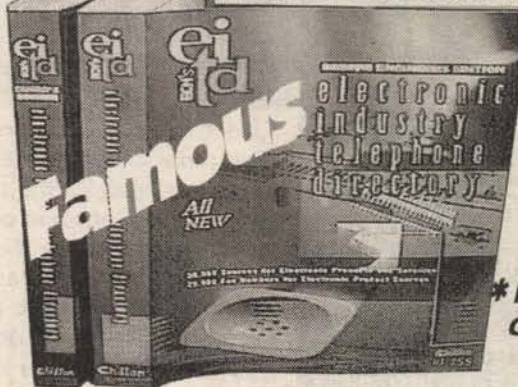
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Nuts & Volts Magazine/February 1997 13



# PORTABLE GPS MAPS GO INLAND

by Gordon West

**O**ur global positioning system, brought to us by the Department of Defense (DoD) and our tax dollars, is so well "received" by the general public that DoD may soon be improving position accuracy by turning selective availability down to zero. Even though the Department of Defense developed NAVSTAR (the original name for the global positioning system) for their own use, and secondarily for civilian use, the number of civilian users throughout the world is so huge that our requests for a more accurate incoming signal are being heard in Washington.

The global positioning system consists of 24 orbiting satellites, circling the earth twice a day in a mid-earth orbit altitude, showing anyone on earth up to an average of seven satellites at any one time. Our earth position is calculated from distance measurements to the satellites based on the velocity of radio waves in free space, as well as the velocity of the radio waves in the not-so-friction-free atmosphere.

This process of tuning into these satellites at 1575 MHz (1.5 GHz) and determining our time delays is called "trilateration." Three satellites will lead to a two-dimension fix, and the fourth satellite will lead to a position fix including altitude.

Closer into shore, mariners might want to turn on their radar, because 300 feet this way or that way could put them on the rocks.

If the Department of Defense turns off selective availability (the slight on-purpose clock errors), position accuracy would shrink from a 300-foot circle down to a 100-foot circle — a three times improvement. Look for DoD to turn selective availability to zero in another couple of years. But not tomorrow.

For civilians needing spot-on GPS accuracy, a differential receiver will do the trick nicely. The differential receiver picks up a local correction signal and automatically adjusts your GPS readout so you are within a five-foot circle.

Mariners can tune into the differential correction signals down on the 200 KHz portion of the band that are broadcast for everyone to receive by the United States Coast Guard. These low-frequency signals penetrate inland only about 100 miles. But they're dandy for a harbor approach.

For police agencies and delivery companies wanting to see exactly what side of the road their vehicles are on, the differential correction signals are sent over sub-carriers on the FM music band. These you subscribe to for a couple hundred bucks a year.

For surveyors, they generate their own correction signals, and now they can get down to a circle the size of a quarter.

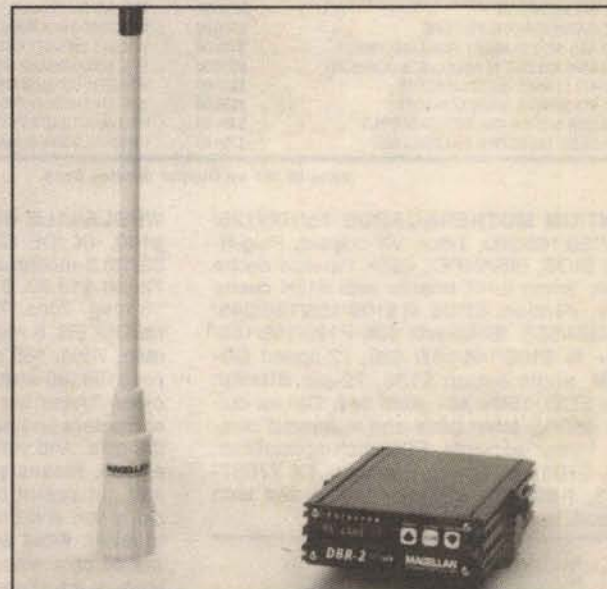
Differential correction signals from the Coast Guard, plus those off of FM sub-carriers, plus those by surveyors, are based on comparisons of incoming GPS derived positions to the known position of a geodetic landmark, and a resulting position error correction signal going out there on the airwaves to a differential beacon receiver that then sends that message on to the GPS receiver to correct its internal calculations.

The largest number of users of low-cost fixed and portable GPS sets are mariners. Low-cost meaning under \$175.00 for a handheld, and under \$275.00 for a fixed-mount set. Mariners were quick to replace Loran and old-fashioned automatic direction finders with new GPS equipment, but still had to do the latitude and longitude manipulations on a marine chart in order to spot their exact position with reference to land.

It wasn't long before marine cartographers started digitizing marine charts, and putting them into a database for big-screen GPS sets to read out ocean and harbor charts with a blinking

"X" showing the position of the boat. And same thing for land — land mapping companies were quick to put every street and every back road of the United States of America onto a CD; and when you tie a CD mapping program into an inexpensive GPS, your computer shows your blinking position all the way down to the smallest of surface streets. But keep in mind, without the subscription differential correction for the roads, your position accuracy will wander around a 300-foot circle. You are sometimes

right on a street corner, and other times a couple hundred feet away. If you subscribe to an FM sub-carrier for your particular city, now you can spot yourself all the way down to a rock-solid "X" right on your driveway!

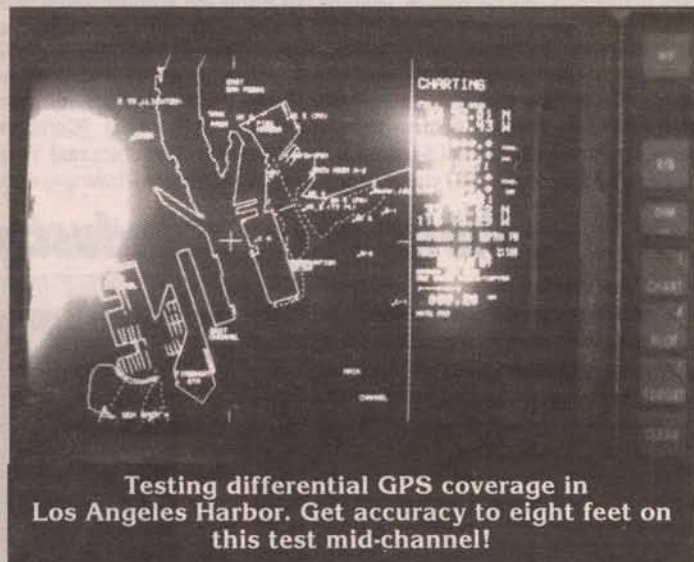


Using signals from marine beacons, the auto scanning, dual-channel DBR-2 DGPS receiver improves the accuracy of GPS to better than five meters RMS, providing precise information for GIS survey and mapping, site-specific farming, boating, sailing, cruising, and other outdoor activities.

Marine manufacturers took their portable GPS equipment into marine cartography with a relatively small, but quite visible, LCD screen. Panasonic and Raytheon were first with a portable GPS set with marine cartography. The actual marine charts were on small plastic cartridges, with Navionics doing a PCMCIA cartridge for the Panasonic GPS, and C-Map doing small cartridges for the Raytheon unit.

**Navionics Electronic Charts; 800-848-5896**  
**C-Map Electronic Charts; 800-424-2627**

Both of these companies are the undisputed "cartridge kings" when it comes to marine information stored on a PCMCIA-style cartridge, or smaller micro- and mini-cartridges that simply plug into a portable GPS receiver. While the detail



Testing differential GPS coverage in Los Angeles Harbor. Get accuracy to eight feet on this test mid-channel!

Today, accuracy of a GPS position fix is within the radius of a 300-foot circle 95 percent of the time. That's one football field. Even though your GPS set might resolve a position fix all the way down to six feet, you will notice that the last digit or two will continuously change — part of the DoD program to deny spot-on accuracy to unfriendly forces, or for that matter, USA civilians with their little GPS receivers.

The 300-foot accuracy 95 percent of the time is just dandy for most mariners well off shore.



Each manufacturer's cartridge will not fit another manufacturer's set. VHS vs. Beta?





Lowrance Global map sport GPS/charting.

found in these small cartridges is nowhere near what you might get out of your lap-top computer on a CD-ROM marine cartridge program, these little cartridges, costing around \$100.00 each, can contain up to 8-15 local marine charts, showing you everything from depth contours to sunken vessels that might be a hazard to navigation.

Recently, two major GPS manufacturers introduced new portable GPS receivers that also show charts from each of these companies on the LCD screen.

Lowrance Electronics offers the Global Map Sport handheld GPS receiver/charting system that runs off of a C-Map mini-cartridge (800-324-4770).

Garmin has introduced their GPSMAP 175 which uses tiny Navionics G-Chart cartridges that show your GPS derived position on the charting

screen (913-397-8200).

These two sets have now become hot-sellers, and it was only a matter of time before each manufacturer decided to focus in on the inland market. Since these sets were selling like hotcakes along the coast lines with marine cartography, how about selling these units inland with local lakes and rivers cartography? The uptake on these under-\$800.00 units was immediate, and the race was on when it came to digitizing inland lakes and rivers throughout the United States.

Navionics said we'll work on it in 1997. C-Map indicated they were working on the bigger populated lakes and rivers now, and take a look at the excellent cartography they have to offer when it comes to certain inland areas.

But GPS giant Lowrance didn't want to wait around, so they began digitizing inland geodetic survey maps, and now offer mini-cartridges called "Inland Mapping System Smart Maps" that contain the names and locations of over 140,000 inland cities; over 60,000 inland national, state, and county parks; and detailed data on over 120,000 inland bodies of water.

You can receive a free map of the USA showing the Lowrance Inland Mapping System chart areas by calling 800-324-0045, catalog "LEI Extras, Inc."

Now here is where it gets a bit complicated — the Lowrance unit takes two small cartridges within its portable package, and one might be C-Map cartography for the local coast line, and Lowrance cartography for the local inland waters. We wanted to see who had the best cartography, so we compared Lake Mead cartography from C-Map and Lake Mead cartography from Lowrance.

The C-Map cartography seemed to have more



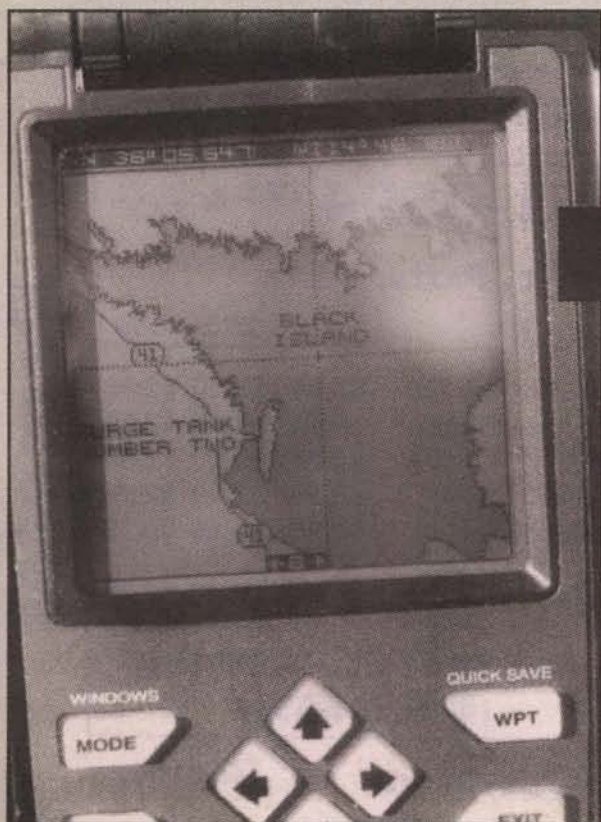
Miscellaneous marine GPS and charting units.

detail, and plenty more underwater analysis of what's happening below the surface. Yet the Lowrance LEI cartridge gave us some additional detail when it came to major highways in the area. This could allow you to use your GPS as a land mapping device while it's sitting on your dashboard, and then use it for a "stay off the rocks" device when out on the boat.

The Lowrance GPS charting equipment can also default to a built-in map of the USA that

Plotter	Lowrance Mini-Format	C-MAP Data on Lowrance Mini-Format	Notes
Global Map Sport	X	X	Accepts Lowrance format only.
Global Map 2000	X	X	Also takes C-MAP cartridge required Maplink.
Eaglebrand Accumap	X	X	Marine unit; not available yet.
AirMap	X	X	Shipped with Jeppesen aviation database; can be enhanced with C-MAP marine data.

Comparison of Lake Mead detail: Lowrance IMS (left) and C-Map cartography (below).



doesn't require any cartridges, and gives all the major highways around the country. Put the little portable Lowrance GPS unit on the dash of your vehicle, and watch yourself go down Highway 101 along the West Coast. While your blinking position may vary by a couple hundred feet along the highway, nonetheless, the Lowrance built-in highway map is good enough to let you know when you're coming up to another major interstate route. No cartridges needed!

The new Garmin unit also looks promising for inland cartography. Garmin is also



producing their own inland maps based on land maps.

The most important thing to remember about marine GPS units operated on land is that you are saving hundreds of dollars on a comparable land GPS unit. You could very well achieve the same accuracy of position, plus show local charts with a \$800.00 portable GPS as compared to a several thousand dollar land-unit GPS set with similar features. And if you arm

yourself with enough inland and ocean cartridges, you should be able to always spot yourself within feet of where you actually are among all the rocks and rivers. And when you're not near land, the Lowrance unit will let you default to the big highway maps, and this will cover you throughout the United States. You can even take your unit to Europe, and spot yourself on land charts in Europe, too, with built-in cartography.

You can also memorize favorite fishing locations on your GPS. Same thing on land — the marine GPS will faithfully track your path as you hike around the mountains, and by following the dots on the screen, you'll always be able to get back to the camp site within the radius of a 300-foot circle.

The marine and camping markets may ultimately push a portable latitude/longitude



Author West testing two portable GPS receivers with cartridge mapping.

(only) GPS to below \$99.00. Right now, you can buy a Magellan or Garmin portable GPS set for less than \$179.00. But for charting, you're going to spend around \$600.00, plus about \$100.00 for each detailed coastal or inland chart of your choosing. But even if you don't buy any chart cartridges at all, the GPS will still accurately show you to your exact position within the radius of a 300-foot circle.

Pick your chart cartridges carefully, and view them before you take out that C note. Then enjoy! **NV**



## INLAND LAKES COVERAGE



### G

- G182.01 GREAT SLAVE LAKE (NW TERR - CANADA)
- G201.00 LAKE TAHOE (CALIFORNIA/NEVADA)
- G229.00 PEND OREILLE (IDAHO)
- G230.00 LAKE MEAD (NEVADA/ARIZONA)
- G239.00 GREAT SALT LAKE (UTAH)

### H

- H129.00 LAKE SIMCOE (ONTARIO)
- H139.00 LAKE CHAMPLAIN TO SOREL (US/CANADA)
- H146.00 LAKE WINNIPESAUKEE (NEW HAMPSHIRE)
- H150.00 LAKE OF THE WOODS/SOUTH (ONTARIO)
- H151.00 LAKE OF THE WOODS/NORTH (ONTARIO)
- H159.00 RED LAKE (ONTARIO)
- H164.00 MILLE LACS (MINNESOTA)
- H165.00 LAKE NORMAN (NORTH/SOUTH CAROLINA)
- H168.00 KISSISSING LAKE (MANITOBA, CANADA)
- H172.00 LAKE OF THE OZARKS (MISSOURI) *To be released shortly*

### J

- J164.01 LAKE TEXOMA (TEXAS/OKLAHOMA)
- J189.00 LAKE LEWISVILLE (TEXAS)
- J191.00 LAKE CUMBERLAND (KENTUCKY) *To be released shortly*
- J194.00 TIMS FORD LAKE (TENNESSEE)
- J195.00 LAKE OUACHITA (ARKANSAS) *To be released shortly*

All of the above listed Inland Lakes cartridges are available for shipment (with the exception of the ones that are marked). These cartridges are priced at a special low price of \$120.00 (USD). If you would like outlines of any of these cartridges, please let us know.

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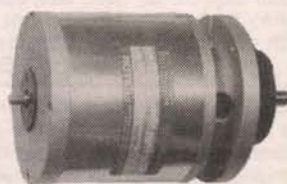
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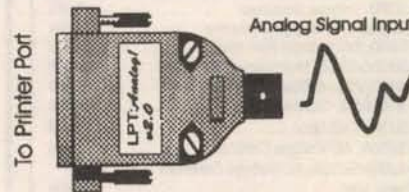
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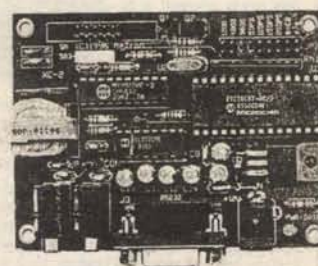
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The New **Motron XC-2** is a versatile bi-directional DTMF to ASCII transceiver. DTMF digits are decoded from the audio line, converted to ASCII, and transmitted out through the serial port. ASCII data is received from the serial port, converted to DTMF digits and transmitted on the audio line. The **XC-2** uses the RS-232C serial communications protocol and includes a PTT output, which can be used to control a radio transmitter. The **XC-2** is user-configurable—select either 1200, 4800 or 9600 baud for the serial port and 5, 10, 15 or 20 cps DTMF transmission rate. Additional jumpers can be used to set DTMF "\*" (on) and "#" (off). Audio connection options allow combined audio signals, or separate audio input and output via standard 3.5mm jacks. A standard DE-9S is used for serial communications. The **XC-2** is a fully assembled and tested printed circuit board, requires +8 to +17 VDC @ 200ma, and is only 2-1/2" x 3-1/2". OEM and Quantity discounts are available.

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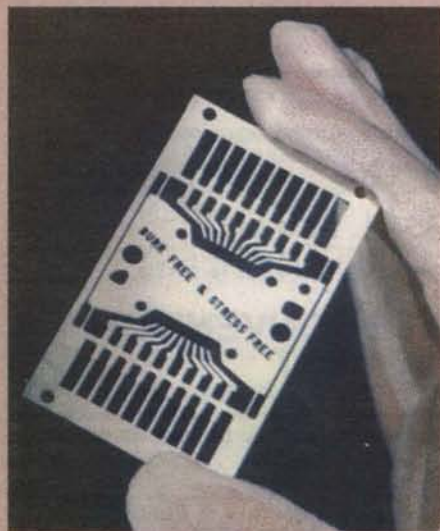
# New Product

Our readers are always looking for new and interesting electronic items. Showcase your NEW PRODUCTS here to help stimulate your product's success. Submit all news releases, product information, and/or photos to:

**NUTS & VOLTS MAGAZINE**  
NEW PRODUCT EDITOR,  
430 PRINCELAND CT., CORONA, CA 91719

## News

### PRECISION METAL PARTS



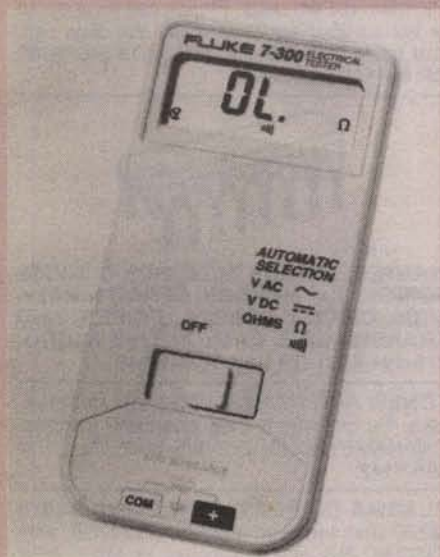
PEI precision etched metal parts are produced by chemical action and feature burr-free and stress-free part numbers and patterns. Unlike conventional metal stamped or machined parts where tooling is subject to wear, these chemically etched parts exhibit no rough edges or deformation, and provide exact repeatability.

PEI precision etched metal parts are priced according to size, material, complexity, and quantity.

For more information, contact:

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508-478-2025 FAX: 508-478-3582

### FLUKE 7-300 ELECTRICAL TESTER



For fast, accurate tests of electrical power, the new Fluke 7-300

Electrical Tester makes the job easy for both entry-level users and for seasoned professionals who want a fast, compact, first-line troubleshooting tool.

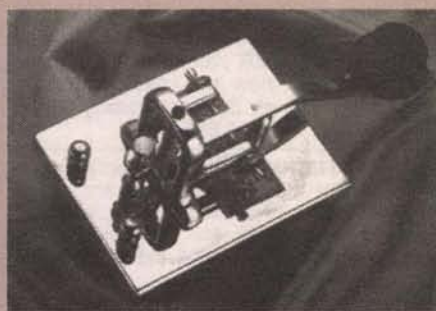
When operating, the Fluke 7-300 automatically switches to the correct setting — volts AC or DC, continuity and ohms — and shows the results on a 4,000 count digital display.

The Fluke 7-300 measures AC and DC voltage to 300 volts. An ideal low-cost, user-friendly meter with high performance, rugged reliability, and quality.

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FAX: 619-779-8171  
WEBSITE: <http://timemotion.com>

### VIBROPLEX® STRAIGHT KEY

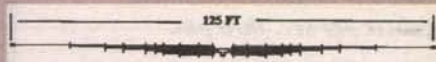


Vibroplex has a Straight Key! A heavy solid steel base anchors the Straight Key to the operating position. The lever arm pivots in the chromed mainframe. A stainless steel tension spring allows complete control of the tension.

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MOBILE, AL 36606-4141  
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1-800-840-8873

### DP-1 ANTENNA



Dynamic Electronics, Inc. announces the development of a new multiband antenna for HF and VHF. The DP-1 covers 80, 75, 40, 30, 20, 17, 15, 12, 11, 10, 6, and 2 meters. It's 125 feet long and has a maximum width of two feet. The eight-dipole elements are made

from #14 insulated stranded wire and are separated by PVC spacers. This trapless antenna has wide bandwidth on each band and can handle maximum power. The insulated wires protect against corrosion and prevent shorting in case a limb or other object falls on the wires. A SO-239 socket is used to accept a standard PL-259 coaxial cable connector. An inverted Vee type installation is recommended with supports at the center and ends.

The DP-1 costs only \$129.00 + \$6.00 shipping to USA and Canada.

For more information, contact:

**DYNAMIC ELECTRONICS, INC.**  
P.O. BOX 896, DEPT. NV  
HARTSELLE, AL 35640  
205-773-2758 FAX: 205-773-7295  
HTTP://www.hsv.tis.net/~dei

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The battery is stainless steel, and the hermetically sealed lithium cell will not leak and destroy the light. It will give short pulses of light (10-30 sec.) for a total of 10 hours. Ten-year shelf life with an operating temperature range of -40° F to 140° F. Battery can be purchased at Radio Shack stores for around \$3.00, part #CR-2032.

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904-587-5172

### MICROCONTROLLER SYSTEM



CG Microsystems announces their new high-speed microcontroller system based on the Dallas DS80C320 MCU (8051 compatible). Designed with versatility and flexibility

in mind, it is ideal for software development, experimental projects, educational needs, robotic projects, process control applications, and many other purposes.

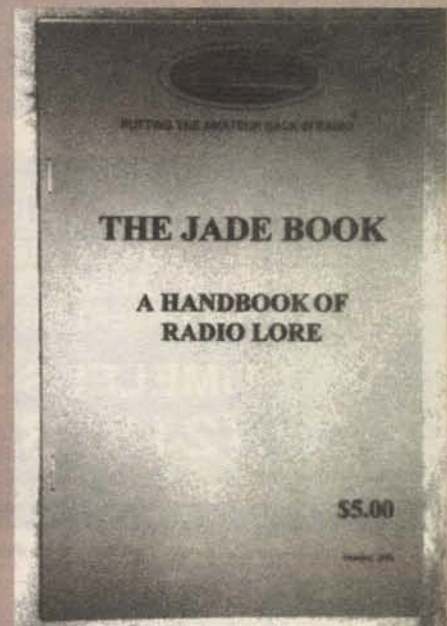
Also included is a monitor/debugger program free of charge. The software provides powerful features for checking out the hardware and provides for loading INTEL hex files to RAM and running programs, viewing the different memory spaces, changing and viewing all internal registers and memory, single stepping, breakpoints, and much more.

Pricing in \$89.00 for a base system (user installs peripherals), or \$149.00 for a full system. Both options include the monitor/debugger software.

For more information, contact:

**CG MICROSYSTEMS**  
P.O. BOX 1074, DEPT. NV  
REDLANDS, CA 92373  
909-793-3917  
<http://home.earthlink.net/~cgmicro/>

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### THE JADE BOOK

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**JADE PRODUCTS, INC.**  
P.O. BOX 368, DEPT. NV  
EAST HAMPSTEAD, NH 03826  
603-329-6995 FAX: 603-329-4499  
E-MAIL:  
[djade@hampstead.k12.nh.us](mailto:djade@hampstead.k12.nh.us)  
<http://www.hampstead.k12.nh.us/~dj>

### MINI-MOD PRODUCTS

Solutions Cubed announces four additions to their mini-mod product line.

The **RAMPack** allows serial storage of data into 8K x 8 (8,192) bytes of RAM. All memory locations

Continued on page 102



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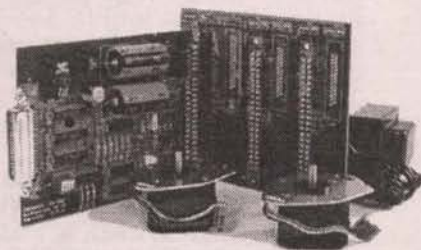
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#### COMPUTER HARDWARE cont.

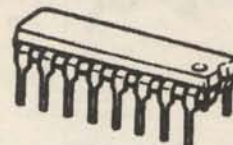
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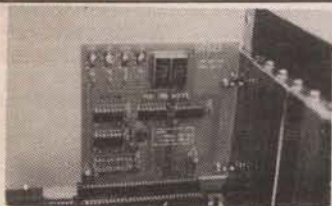
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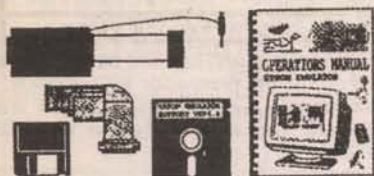
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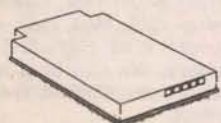
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motherboard, supports 3.4 or 5V CPU, at either 25 or 33 mhz basic clock. Can use AMD or Intel from 486SX25 thru 486DX4-100 to HOT new AMD 5X86-133 cpu. On board SVGA video. On board 1 meg video ram expandable to 2 meg with ATI Mach 2 chip set. On board 2 high speed serial ports, 1 printer port, floppy and IDE hard drive controller. On board 256K cache. Uses 72 pin simm memory. Landmark speed rating of 479 with AMD chip.

Board will not fit standard All in One case because of non standard location of riser board. VLB riser board is included with motherboard.

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Unit is for Hi Band 8mm CamCorders, includes 8X zoom lenses, D/D converters, built-in CCD 2/3 in, 420 thousand picture elements, complementary mosaic filters. Excellent performance. High resolution, high sensitivity, low lag, low smear, good color reproduction, no distortion, 1/60-1/1000sec variable speed digital shutters, TTL auto focus, auto white balance, one-push auto white balance, auto/manual iris and gain up switch. Can be controlled by a 4bit micro computer. Remote controlling is possible for zoom and focusing. NOTE: We have Composite or PAL (European Standard) Units. MFR: SONY

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Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **\$89.00**

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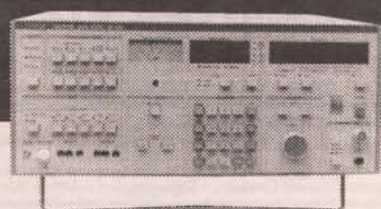
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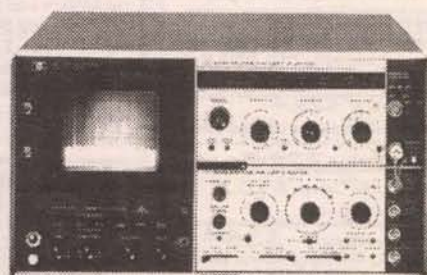
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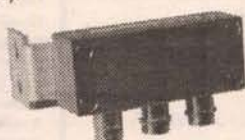
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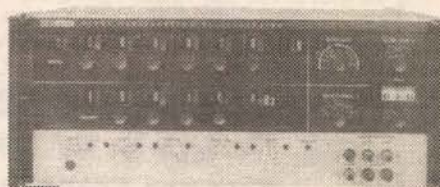
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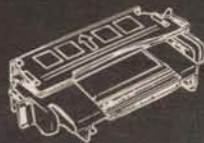
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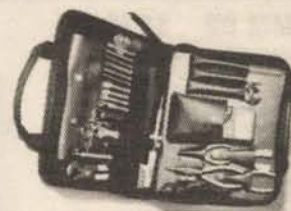
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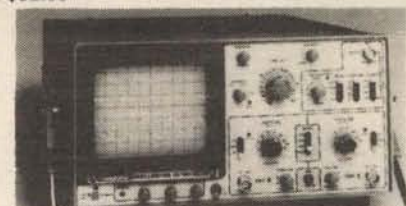


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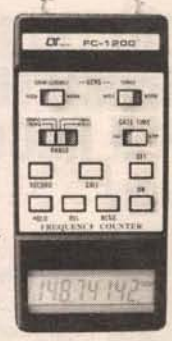
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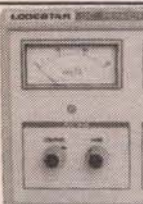
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# Stamp Applications!

## Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

by Scott Edwards

**F**or \$30.00 or less, you can connect your Stamp project to the biggest communication network on the planet — the global phone system. All you need is a modem and a few tricks of the trade. This month, we'll look at the powerful "AT" modem-control language with an example application that lets you access Stamp data as easily as logging onto a computer bulletin-board system (BBS) or online service. In BASIC for Beginners, we'll add a display and other features to our three-lane race timer.

### Modem Lets Stamps Access Global Communication Network Dialing for Stamp Data and Beginner's Race Timer with Display

#### Modem Fundamentals

A modem is a small, fast computer specialized for sending and receiving serial data across the phone lines in the form of audio tones. At low data rates, shifts in the frequency of the tones convey individual bits of data; at higher rates, changes in phase and/or amplitude of the signal represent multiple bit combinations.

The word modem is a compaction of modulator/demodulator. Impressing data onto tones is modulation; extracting data from modulated tones is demodulation.

The modem's computer is programmed with routines to dial the phone, detect ringing and busy signals, establish a connection with another modem, exchange data, and hang up. It has all kinds of settings for dealing with subtle variations in phone procedures and user preferences. In fact, a modem has more settings, options, instructions, and raw computing power than the BASIC Stamp II (BS2) that we'll be using to boss it around!

Almost all modems use some variation of the "Hayes" command set, named for the company that set the standard for modems in the early days of personal computing. This control language is also sometimes called the AT command set, because most commands begin with AT (for "attention," or so the story goes).

A modem has two modes of operation: command mode and data mode. When the modem is not linked to another modem, it's in command mode, awaiting instructions from the local computer. The computer can instruct the modem to dial out or answer a call from another modem. When two modems initially make contact, they investigate each other through handshaking — a ritual exchange of tones and preliminary data that sets the ground rules for communication.

Once handshaking is complete, the modem goes into data mode. In data mode, it acts like a direct connection between local and remote computers. Once in data mode, a modem ignores commands unless it is first returned to command mode by a sort of secret knock (usually "+++"). Otherwise, it would be impossible for modem users to communicate about modem commands without their modems trying to carry out those commands!

When the exchange of data is complete, one of the computers issues the secret knock to return its modem to command mode, then instructs it to hang up. The other modem senses this loss of carrier, and hangs up too.

#### Meet Your Modem

The modem you'll need for Stamp applications is an external modem — one designed to be connected through a serial port, not

installed inside a desktop computer (internal). If you don't have one, let me suggest Jameco part no. 132206, a 9600-baud external modem with power supply and cable for \$29.95 (Sources). This is an older unit that may not be available forever, so keep your eye open for bargains on similar external-style modems.

A benny of buying an older modem is that it usually comes with a good manual on the AT command set. In the old days users generally dealt directly with the modem, manually typing commands through a terminal program. The manuals that come with newer modems assume that you're using more helpful software and therefore require less technical data.

To really understand how a modem works, you should try using it manually with your PC and terminal software. If you have Windows installed, there's a simple terminal "accessory" program. Procomm is a popular commercial package, available in both DOS and Windows flavors.

Although the modem manual lists dozens of commands, you can get by with knowing a few important ones. Table 1 lists the ones I found helpful in getting the Stamp on line. Once your terminal program is set up and talking to the modem, you may send commands by typing them at the keyboard. For example, if you type "ATDT 5551234" followed by the Enter key, the modem will go off-hook (connect to the phone line) and send the touch-tone digits 555-1234.

#### Configuring and Using the Modem

Once you know how to send commands to the modem, you can configure it to work in our example BS2 application. As Figure 1 shows, we're

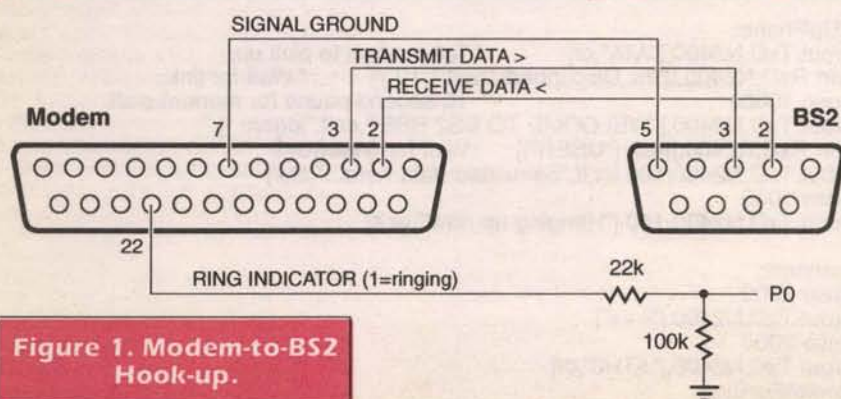


Figure 1. Modem-to-BS2 Hook-up.

Table 1. Some Useful AT Modem Commands

Instruction	Operation
ATDT n	Dial n using touch tones. ATDT 4594802 dials 459-4802. The number to dial can include other symbols that change way it is dialed, including: ; Pause dialing W Wait for second dial tone ; Stay in command mode after dialing
A/	Repeat last command entered.
ATH0	Hang up.
ATA	Answer the phone now (manual answer).
ATV0	Set modem responses to numbers (0-10).
ATV0	Set modem responses to words (e.g., CONNECT 2400).
ATZ	Return modem to default settings.
AT&W	Store configuration settings to non-volatile memory.
ATS0=0	Turn off auto-answer function.
ATS0=n	Turn on auto-answer and set for n rings.
ATM0	Silence speaker.
ATM1	Turn speaker on while dialing; off during communication.
ATE0	Do not echo commands.
ATE1	Echo commands.
+++	Escape command: shifts modem from data to command mode after a preset time delay (set by register S12).
ATS12=n	Set escape (+++) delay to n number of 20-millisecond units. For example, ATS12=50 sets the escape delay to 1 second.



# Stamp Applications:

using the BS2's serial programming port to talk to the modem. A peculiarity of this port is that everything sent to it on the serial-in line is sent back to the serial-out line. Modems are factory configured to do the same thing.

If you take a modem out of the box and have a BS2 send it a command, the modem will echo the command. The BS2 will echo the echo, which the modem will echo, which the BS2 will echo ... to infinity and beyond, if I may quote Buzz Lightyear's catchy motto.

A further catch is that this loop effect prevents the BS2 from issuing the ATE0 (no-echo) command. You must configure the modem properly before it will understand anything the BS2 has to say.

Listing 1 includes a table of configuration commands to send to the modem to prepare it for use with the BS2. Once the modem is configured, you should use the AT&W command to commit the configuration to non-volatile memory so that it is preserved after the modem is turned off and back on.

As you can see from the program listing, it is possible for even a very simple program to answer the phone, establish a link, and communicate by modem. You can use this program as a basic framework for your own applications.

## Advanced Applications

If you decide to develop modem-based applications, you will almost certainly need a telephone-line simulator. I used the Digital Products Company Party Line unit, which I built from a kit (Sources). If your construction skills are at the beginner level, or you tend to disregard instruction manuals, I recommend buying the assembled version. It's not a difficult kit, but the large number of components may exceed short attention spans.

Although I demonstrated how to receive a call, you can use the same principles to have the Stamp dial a call and log onto a BBS or on-line service. Most of the work in developing this kind of application would be in carefully documenting the

log-on procedures for the Stamp to follow.

Don't overlook the fact that modems allow you to access other phone services. You can dial pagers or automated touch-tone menus and send them sequences of tones. The manual I received with the Jameco modem provides an example under the heading "Dialing a Voice Call/Sending Tones as Data."

In your applications, make sure to take advantage of the BS2's Serin timeout feature. If no data is received within a set period of time (up to 65+ seconds), the BS2 can abort the Serin operation. You can see an example of this in Listing 1 when the program is listening for the connect code ("10"). If no connect occurs within 10 seconds (set by the constant tLink), the program hangs up and waits for another call.

My final hint: Use the lowest practical data rate in modem comms. The faster the rate, the more fragile the link. You can spend your nights and weekends writing clever and elaborate error-detection and correction code, but that code can grow to overwhelm the Stamp's program memory. Also, at very high data rates, the Stamp may be unable to recognize longer WAIT sequences (like the password "USER" in Listing 1). I've received credible information to this effect from a seasoned BS2 user, and I'll investigate the problem (and provide a solution) in a future column.

## BASIC for Beginners

In the column before last (no. 22, Dec. '96), we developed a prototype three-lane race timer for

## Sources

For more information on the BASIC Stamp, contact:

### Parallax, Inc.

3805 Atherton Road, #102, Rocklin, CA 95765

phone (916) 624-8333

Internet <http://www.parallaxinc.com>

Digital Products offers the Party Line phone-line simulator used to develop and test the modem application for \$199.95 in kit form (add \$32.95 for a nifty case) or \$425.00 fully assembled and tested. They also offer other phone-related electronic kits and products.

### Digital Products Company

134 Windstar Circle, Folsom, CA 95630

phone 916-985-7219; fax 916-985-8460

E-Mail: [DigProd@aol.com](mailto:DigProd@aol.com)

Jameco sells the inexpensive modems used in this application.

### Jameco Electronic Components

1355 Shoreway Road, Belmont, CA 94002-4100

phone 415-592-8097 or 800-831-4242

fax 415-592-2503 or 800-237-6948.

The 2x16 Serial LCD Module used in the race-timer example is available from Scott Edwards Electronics for \$45.00 plus shipping. Other serial LCDs up to 4x40 lines-x-characters are available. The same source also offers the LCD Serial Backpack, a daughterboard that converts any alphanumeric LCD module up to 80 characters to serial operation. Manufacturers can purchase the Backpack chip for incorporation into their own products for less than \$4.00 in quantity.

For a catalog of Stamp-related products, contact

### Scott Edwards Electronics

P.O. Box 160, Sierra Vista, AZ 85636-0160

phone 520-459-4802; fax 520-459-0623

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## Listing 1. BS2 Program to Demonstrate Modem Interface

' Program: ANSW\_MDM.BS2 (Answer modem and exchange data)

' This program demonstrates how the BS2 can be used with  
' an AT/Hayes-compatible modem to link up with incoming  
' modem calls and exchange data. It uses the programming/  
' downloading serial port plus one I/O line for the modem  
' hook-up. Before this program can be used, the modem must  
' be configured to work with the BS2's serial port by  
' disabling echo-back of commands. (Failure to do this  
' will cause the modem's RD and SD lights to stay lit  
' continuously and the modem to become locked up.) Prepare  
' the modem by connecting it to a PC running terminal  
' software at 2400 baud, N81, full duplex. Send the modem  
' configuration commands, as follows.

Type this command	Modem Responds	Purpose/Effect
ATS0=0 <Enter>	"OK" or "0"	Disable auto-answer
ATS12=50 <Enter>	"OK" or "0"	Set "+++" response to 1s
ATV0 <Enter>	"0"	Set number responses
ATE0 <Enter>	"0"	Disable command echo
AT&W <Enter>	"0"	Memorize configuration

' After the ATE0, your typing won't be visible on the screen  
' unless you reconfigure the terminal for half-duplex.  
' These settings are stored in non-volatile memory, so the modem  
' does \_not\_ have to be reprogrammed if power is turned off.  
' Connect the BS2 to the modem as follows:

BS2	Modem DB25
DB9, pin 2	pin 2
DB9, pin 3	pin 3
DB9, pin 5	pin 7
I/O pin P0 (thru 22k resistor)	pin 21

' Turn the modem on first, then the BS2. When the phone rings,  
' the BS2 will instruct the modem to answer and try to establish  
' a connection. If connection is successful, the remote computer  
' will see a sign-on message and be prompted for a password ("USER").  
' The BS2 will then transmit a simulated batch of data. When the  
' BS2 hangs up, the remote computer's modem will hang up too, ending  
' the exchange.

Variable	Value	Description
con	10	Linefeed character to format data.
tLink	10000	# of milliseconds to wait for link up.
N2400	16780	Baudmode for 2400 bps inverted.
TxD	16	Pin to output serial data.
RxD	16	Pin to input serial data.
RI	var	Ring-indication output of modem.

waitForRing: ' When phone rings, RI goes high.  
if RI = 0 then waitForRing ' Wait here while RI is low.

pickUpPhone:  
serout TxD,N2400,["ATA",cr] ' Tell modem to pick up.  
serin RxD,N2400,tLink,Disconnect,[wait ("10")] ' Wait for link.  
pause 10000 ' 10-second pause for modem stuff.  
serout TxD,N2400,["WELCOME TO BS2 BBS!",cr,lf,"logon: "]  
serin RxD,N2400,[wait ("USER")] ' Wait for password.  
serout TxD,N2400,100,[cr,lf,"Simulated data here...",cr,lf]  
pause 1000  
serout TxD,N2400,100,["Hanging up now.",cr,lf]

Disconnect:  
pause 2000  
serout TxD,N2400,["+++"]  
pause 2000  
serout TxD,N2400,["ATH0",cr]  
goto waitForRing



# Stamp Applications:

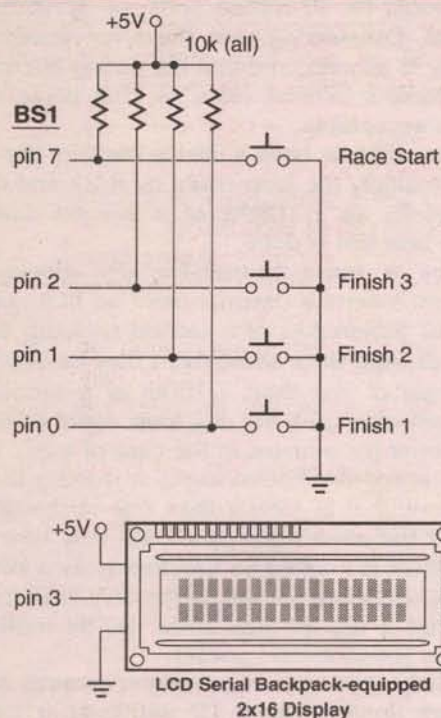


Figure 2. Race timer schematic.

wood and raced on an inclined track.)

In its previous state of development, the program could track the individual finish times of three cars in terms of the number of timing loops and display the loop counts on the Debug screen. Our next hurdles are to free the program of the PC by giving it a stand-alone display, and to convert its loop-count values into seconds.

For the display, I chose the 2x16 Serial LCD Module that my company makes. Aside from the

fact that they're readily available, these LCDs look slick, can display mixtures of words and numbers, and are easy to drive with the Stamp's Serout instruction. Setting aside my obvious bias, I think you would be hard pressed to find a better display for the purpose.

Interfacing the display to the Stamp consists of connecting ground, +5V, and one Stamp input/output (I/O) pin. To print text to the display, output it serially through the appropriate I/O pin at 2400 baud, inverted:

```
Serout 3,N2400,("RACE IN PROGRESS")
```

To print the value of a variable, use this form:

```
Serout 3,N2400,(#time1)
```

That assumes that the variable named time1 is already defined using the Symbol directive. See Listing 2 for examples.

The serial LCD also accepts instructions that control how it displays data. There's a list of instructions in the manual, but many applications get by with just two: clearing the screen and positioning the cursor. To tell the display that an instruction is coming, just precede it with a byte containing 254, like so:

```
Serout 3,N2400,(254,1)
```

The 254 alerts the display to expect an instruction; 1 is the instruction to clear the screen. After the instruction, the display returns to data mode.

Positioning the cursor works similarly. The 2-line by 16-character (2x16) LCD screen is mapped to a set of addresses. The first line consists of addresses 128 through 143; the second, 192 through 207. Each of these addresses is a byte of

RAM in the LCD controller. The LCD has additional RAM (a total of 80 bytes), but locations outside the ranges mentioned above are not visible on a 2x16 display.

To set the printing location to a particular spot on the screen requires sending the instruction prefix followed by the screen address:

```
Serout 3,N2400,(254,200)
```

The cursor moves to address 200, which is character 8 of the screen's second line. (The manual that comes with the display includes a map of the whole screen, so it's not necessary to memorize this stuff.) The program in Listing 2 uses just these clear-screen and cursor-position instructions to organize the race-time data on the display.

Now that we have a way to display data without the PC, we need to do some work on the data itself. The prototype program expresses racing time in terms of the number of program loops executed before a racer crosses the finish line. By running that program and comparing the loop values to stopwatch time, I found that 338 loops equal one second. A straightforward way to convert loops to seconds would be to divide by 338.

Since the Stamp deals only in integer math, race results would be only in whole numbers of seconds; 1,2,3... It's reasonable to expect that many races would be decided by a margin of a fraction of a second. We want our timer to report times with appropriate precision.

The first improvement to consider would be moving the decimal point. Instead of reporting seconds, how about tenths or hundredths of a second? The program executes 33.8 loops every 1/10th second or 3.38 loops every 1/100th. To

## Listing 2. BASIC for Beginners Race Timer with Display

' Program RACE2.BAS (Three-lane race timer with display).  
' This program shows how the BS1 (or Counterfeit) can  
' be used to time a three-lane Pinewood Derby race.  
' It converts a raw count of program loops into  
' units of 1/100th of a second and presents them on  
' a serial LCD display.

```
SYMBOL time1 = w2      ' Word variable for lane-1 time.
SYMBOL time2 = w3      ' Word variable for lane-2 time.
SYMBOL time3 = w4      ' Word variable for lane-3 time.
SYMBOL start = pin7    ' Start-switch on pin 7; 0=start.
SYMBOL status1 = bit0  ' Status of lane 1; 1=racing, 0=done.
SYMBOL status2 = bit1  ' Status of lane 2; 1=racing, 0=done.
SYMBOL status3 = bit2  ' Status of lane 3; 1=racing, 0=done.
SYMBOL win = bit3      ' Flag to indicate race winner.
SYMBOL stats = b0      ' Byte variable containing status bits.
SYMBOL pos = b11       ' Printing location.
SYMBOL digits = b10    ' Digits to display.
SYMBOL timeDat = w1    ' Timing data to convert/display.
SYMBOL iPre = 254      ' Instruction prefix for LCD.
SYMBOL clrLCD = 1      ' Clear LCD screen.
SYMBOL blank = 8       ' Blank the LCD (but retain data).
SYMBOL restore = 12    ' Restore LCD.
SYMBOL topLft = 128    ' Move to top-left of LCD screen.
SYMBOL topRt = 136     ' Move to top-right of LCD screen.
SYMBOL btmLft = 192    ' Move to bottom left of LCD screen.
SYMBOL btmRt = 200     ' Move to bottom right of LCD screen.
```

```
begin:
  stats = %111          ' All cars in the race to begin.
  time1=0:time2=0:time3=0 ' Clear timers.
  serout 3,n2400,(iPre,clrLCD) ' Clear the display.
  pause 5
  ' The line below is sneaky — it prints "Race in Progress" to the
  ' LCD, then blanks the LCD so that the message is hidden. That
  ' way, the program can display the whole 16-byte message by just
  ' sending a 2-byte 'unblank display' instruction.
  serout 3,n2400,("Race in Progress",iPre,blank)
```

hold:

```
if start =1 then hold
serout 3,n2400,(iPre,restore) ' Restore "Race in Progress" to LCD.
```

```
timing:
  stats = stats & pins & %111
  if stats = 0 then finish
  time1 = time1 + status1
  time2 = time2 + status2
  time3 = time3 + status3
  goto timing
```

```
finish:
  serout 3,n2400,(iPre,clrLCD) ' Clear display.
  pause 5
  serout 3,n2400,(iPre,btmRt,"-FINAL-") ' Print FINAL.
  timeDat=time1: pos=topLft:gosub Display ' Display race times.
  timeDat=time2: pos=topRt:gosub Display
  timeDat=time3: pos=btmLft:gosub Display
```

```
END ' End program — reset to time another race.
```

```
' This subroutine converts the loop count in the variable timeDat
' into a number of hundredths of a second, then prints that value
' (as seconds, with decimal point) at the screen location specified
' by the variable pos.
```

```
Display:
  serout 3,n2400,(iPre,pos) ' Move to display location.
  if timeDat > time1 OR timeDat > time2 OR timeDat > time3 then noWin
  serout 3,n2400,(" ") ' Put * by winner (or winners, if tie)
  goto skip1
noWin:
  serout 3,n2400,(" ") ' Put space by non-winners.
  skip1:
  timeDat = timeDat*8/27
  digits = timeDat/100
  serout 3,n2400,(#digits,".") ' Convert to 100ths of a second.
  digits = timeDat/100 ' Print hundreds place followed
  if digits > 9 then skip0 ' ..by decimal point.
  serout 3,n2400,("0") ' Now print remainder.
  skip0: ' If remainder is less than 10,
  serout 3,n2400,(#digits) ' ..print "0" (i.e., convert
  return ' "6" to "06" for correct display.
  ' Return to program.
```



# Stamp Applications:

convert loops to 1/100ths, just divide by 3.38. Oops — there's that integer math limitation again. The Stamp can divide by 3 or 4, but not by 3.38. Dead end? Not quite.

Another way of looking at a division problem is to consider it as multiplication by a fraction. Dividing a number by 3, or multiplying it by one-third, has the same effect. And the Stamp can multiply by a fraction, which is nothing more than integer multiplication followed by integer division. The trick is to find an integer fraction that's equal to 1/3.38.

There are lots of ways to approach this problem, but I find that common sense favors this method: (1) Estimate the largest value of the numerator (the "1" in 1/3) that can be used without exceeding the maximum variable size; (2) For each integer up to the maximum, pick a likely candidate for the denominator and calculate the result.

An example will make this clear. For step 1, the largest numerator depends on the size of a Stamp word variable (65535 max), the number of loops per second (338), and the maximum number of seconds we wish to measure. If we want to measure times up to 20 seconds, then the maximum value for the numerator is

$65535/(338*20) = 9$ . That narrows our search considerably.

In step 2, for numerators from 1 to 9, we're looking for denominators that make the fraction as close as possible to 1/3.38 (0.295858). That's pretty close to 1/3, so candidate denominators should be between three and four times the numerator. Simplified this way, we can quickly run the numbers on a hand calculator, or create a spreadsheet or PC program to do it for us. In this case, the number of trial values is small:

Numerator	Denominator	Result	Error %
1	3	0.333	+11
1	4	0.250	-15
2	7	0.286	-3.4
3	10	0.300	+1.4
4	13	0.308	+4
5	16	0.31	+5.6
5	17	0.294	-0.6
6	21	0.286	-3.4
7	23	0.304	+2.87
7	24	0.292	-1.4
8	27	0.296	+0.15
9	31	0.290	+0.29

The fraction 8/27 gives us the smallest error, just 0.15 percent. Over the course of a 20-second race,

that would be 30 milliseconds, or 3/100ths of a second. Considering that the error would apply equally to all cars, and that the timing accuracy of the Stamp's internal clock is  $\pm 0.5$  percent, that seems acceptable.

Now that we have a usable fraction, the rest is easy; multiply the loop count by 8/27 and display the results as 1/100ths of a second. Listing 2 shows how this is done.

For a more human-friendly display, the program inserts a decimal point so that numbers like 891 hundredths of a second show up as 8.91 seconds. And since some races may be decided by a margin of less than 1/100th of a second, the program also uses the raw loop count to declare the winner (or winners, in the case of a tie). It uses a process-of-elimination logic, reasoning that any race time that is greater than one or the other or both of the other times is a loser. Any time that's not a loser is marked on the display as a winner. If there's one winner, it will be the only time marked. If there's a tie, the tied times will be marked as winners (co-winners, I guess).

That wraps up our race-timer project, at least for now. In the future, I'll use it as a basis to demonstrate different display techniques, hardware timing options, sensors, etc. **NV**

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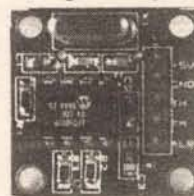
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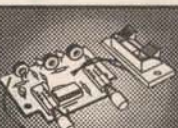
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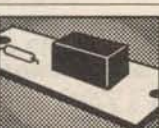
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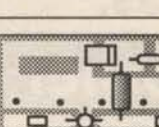
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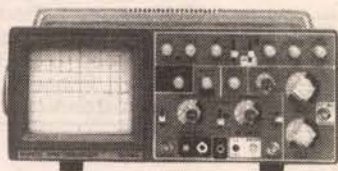
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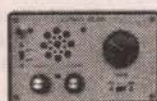


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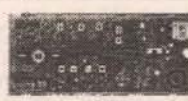
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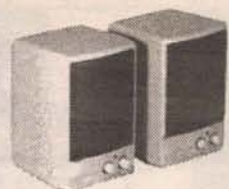
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# THE NUTS & VOLTS SOLAR WORKSHOP

Welcome to The N&V Solar Workshop ...

## A 50-Watt Photovoltaic Installation — Part 1

Please find a seat while I hang these charts on the wall. No, you didn't accidentally stumble into the Classroom. This is the Workshop, and these are just wall-size worksheets of tonight's project. There, that's the last of them.

I'm glad you could make it back to the N&V Solar Workshop for this, our fourth session, because we're about to tackle a project that realistically demonstrates the real-life practicality of photovoltaics. If you attended our last Workshop, you learned how to design and build a small, 12-watt photovoltaic system capable of powering automatic sprinklers or steering a satellite dish. Cute, but limited in application. In this, and next month's Workshop, we're going to up the ante to 50 watts, which is enough wattage to power a small ham shack or experimenter's workbench.

I see that we have a few new faces in the crowd, and I'd like to welcome them to the group. Among our guests is Jim Tolson, an avid ham operator with an impressive QSL collection wallpapering his radio shack. He has an interesting story of how he converted his QRP radio shack from utility-powered to solar-powered. In fact, he will host this month's Classroom. Don't miss his lecture! He relates 20 years of hands-on experience in a must-read for anybody serious about solar power. Ready? Let's begin.

## The Workshop

### A 50-Watt Solar Installation

Over the past few months, the Workshop projects have been getting more sophisticated and more powerful as our knowledge of photovoltaics grows. This time, we're going to explore all the "minor" details it takes to boost the power level from watts to tens of watts.

You may be surprised to learn that some of the things we can ignore at 12 watts become major design concerns at 50 watts and better.

For example, the threat of battery explosion or an electrical fire is virtually nonexistent when working with a 12 Ah (amp-hour) battery powered by a 1 amp, 12-watt solar panel. It just doesn't

happen. A 50-watt solar installation, on the other hand, has the potential for both unless you pay attention to the details of the design.

To get a handle on the potential of a 50-watt solar generator, we need to put things into perspective. In my search for the perfect sample scenario, it occurred to me that a significant number of N&V readers are also hams — radio amateurs — with an insatiable thirst for the offbeat and the unexplored. So let's see what it takes to solarize a typical ham shack.

Before we begin, let me point out that the ham shack we're talking about is a QRP operation where RF output levels seldom exceed 50 watts — but herein lies the challenge of the sport: Talking to people on the other side of the world without the power of "Voice of America." This design is applicable to other hobbies, too, as you'll see as our system takes shape.

### Follow The Bouncing Photon

Why 50 watts, you ask? Because it's a nice, affordable power platform that doesn't take a rocket scientist or deep pockets to assemble. The design procedure involves six very defined stages: the solar array; charge controller; battery array; battery monitor; power distribution; and last — but far from least — safety concerns.

As always, we design from the back forwards, starting with the system's load requirements and ending at the photovoltaic array.

A typical approach is to define the parameters of each stage using a worksheet, like you would when you set out to draw up a monthly budget plan. This is the approach we'll use for this design, and the reason for the charts on the wall.

### System Loads Worksheet

The first chore is to list our liabilities, or power requirements. Let's assume that you're a typical DXer who spends more time listening for that elusive contact than running off the mouth. This behavior gives us two distinct power levels: the amount of power consumed on standby; and the power used during transmission. Let's make these the first two entries in our System Loads Worksheet shown in Table 1. We'll call them "Transceiver" for listen and "Linear" for send.

I don't know about you, but I gave up candlelight a long time ago in favor of overhead electrical lighting (I'll go into lighting details later in this discussion). A well-equipped ham shack also needs support equipment, like a keyer or signal processor. So let's add these two items to the worksheet.

Lastly, we have to factor in the cost of doing business. It's listed as "System Overhead," and includes the power used by the various monitoring and safety devices. You'll find the current requirements for all the above devices in the Current Draw column of our worksheet.

Now that we have a list of the power users, it's time to assign power-consumption values to them. These values are measured in amp-hours, which is the product of current x time. Let's say, for example, that we use the ham shack for an average of three hours per evening, five nights a week. The first thing I do when entering the room is turn on the lights and the rig — in that order. It's also the last thing I do, in reverse order, so it's a constant.

Together they consume 9 Ah (6 Ah + 3 Ah, respectively). The auxiliary equipment and system overhead adds another 5 Ah to the total (3 Ah + 2 Ah). The final factor is the amount of time spent talking, which I guesstimate at

20 minutes per evening, for another 3 Ah. You'll find these amp-hour values in the fourth column (Average Battery Use Per Session) of our worksheet.

To arrive at an average weekly total, we simply multiply the amp-hour values by the number of days. Pay careful attention to the system overhead value, which goes on seven days a week, 365 days a year, come rain or shine. The other values are calculated on a five-day week usage. The grand total is 89 Ah per week.

### Battery Sizing Worksheet

The next step is to select a suitable battery for the task at hand. While it may seem that this question has been answered in the System Loads Worksheet above, there are other factors involved — specifically, temperature.

As the temperature drops, so does the battery's capacity to store power. Ideally, the battery should be snuggled in a nice, warm place, like the corner of your workshop. However, this isn't always practical — or advisable! If you were around in December for our Workshop on batteries, then you'd remember that lead-acid batteries "boil" off small amounts of hydrogen gas.

In case you haven't heard, hydrogen gas is violently explosive. In fact, it was a small spark that sent the famous hydrogen-filled dirigible Hindenburg to its fiery fate. The same could happen to your radio room if you're not careful. So for safety's sake, it's smart to locate the battery in a well-ventilated place, like the garage, instead of under your workbench.

This means that the battery has to be oversized to compensate for changes in the weather. Let's say the battery is in an unheated garage with an average temperature of 50°F. The chart in Table 2 lists the Battery

Load	Current Draw	Average Session Usage	Average Battery Use per Session	Weekly Total (based on 5 days)	Table 1. System Loads Worksheet
Transceiver (10W)	1 amp	3 hrs	3 Ah	15 Ah	
Linear (50W)	10 amps	20 min	3 Ah	15 Ah	
Aux. equipment	1 amp	3 hrs	3 Ah	15 Ah	
Lamp (22W)	2 amps	3 hrs	6 Ah	30 Ah	
System overhead	0.125 amp	15 hrs (daily)	2 Ah (daily)	14 Ah (7 days)	
Total Use				89 Ah	

Table 2. Battery Temperature Multiplier

Temp Fahrenheit	Temp Centigrade	Multiplier
80°F	26.7°C	1.00
70°F	21.2°C	1.04
60°F	15.6°C	1.11
50°F	10.0°C	1.19
40°F	4.4°C	1.30
30°F	-1.1°C	1.40
20°F	-6.7°C	1.59

Table 3. Battery Sizing Worksheet

Description	Value
Weekly Ah usage	89 Ah
Battery temperature	50°F
Battery temperature multiplier (from Table 2)	1.19
Preliminary battery capacity (weekly Ah x temp multiplier)	106 Ah
"Rainy day" reserve power (about 40%)	44 Ah
Final battery capacity	150 Ah



# THE NUTS & VOLTS SOLAR WORKSHOP

Temperature Multiplier for temperatures from tropical to arctic. The correction factor for 50°F is 1.19. When we multiply 89 Ah by 1.19, we get 106 Ah, the battery size we'll need to store 89 Ah in our cold garage. If we are forced to set the battery outside (not a recommended practice) where the night temperatures can dip to below 40°F, we would need to buy a 116 Ah battery to reach our 89 Ah goal. These numbers are now added to our Battery Sizing Worksheet shown in Table 3.

So far, we've assumed that the battery gets a daily dose of charge. But in real life that doesn't happen. It rains, it snows, and sometimes the weather gets downright nasty, during which time no solar power is generated. To help us through rainy days and Monday doldrums, we have to increase the capacity of the battery. If we used the shack every day, you'd want to double the battery capacity to 200 Ah. But we don't use it everyday, so we can be more conservative. If we increase the capacity from 106 Ah to 150 Ah, we should be able to make it through a week of no sunshine before starting to worry about running out of juice.

## Photovoltaic Sizing Worksheet

The last calculation we have to make before proceeding with our design is sizing the photovoltaic panels. We'll be using the Photovoltaic Sizing Worksheet in Table 4 for this step.

First, we have to calculate our average daily amp-hour usage by dividing the weekly consumption (89 Ah) by seven, which nets us 13 Ah. Next, we determine the current needed to achieve 13 Ah per day. We do this by dividing daily usage (13 Ah) by our insolation factor (the average number of productive solar hours per day). Let's call the insolation factor 5.0. This gives a charging current of 2.6 amps, which converts to 37 watts when we multiply the charging current by the charging voltage (14.2 volts).

Finally, we have to compensate for system losses and changes in the weather. There are no set rules here. For example, you have to put back about 10 percent more power than you take from the battery, which amounts to 3.7 watts. Losses in the wiring accounts for another two percent,

which rounds off to one watt.

For the weeks of December 7 through January 4, the shortest days of the year, the insolation factor is down about 1.0 below the yearly average. Let's add another 20 percent to get by these lean times. And we'll toss in another three percent to make up for whatever we forgot, giving us a 35 percent "cushion" of 13 watts. This figure is now added to our average daily wattage, which brings us up to 50 watts total.

## Off To The Solar Mart

It's time we did some shopping, just to see what's available and how much it costs. Our biggest expense will be the photovoltaics, so let's start there. For this chore, I let my fingers do

the walking through the pages of several alternative energy catalogs and came up with a list (Table 5) of likely candidates. For more information on photovoltaic type and expected lifespan, check out the Dec. '96 issue of The N&V Solar Workshop. Plan on spending about \$300.00, whatever your choice.

The next most expensive item is the battery array, which will cost you anywhere from \$140-\$400, depending on where you shop and the type of battery you select (flooded, sealed, etc.).

For more information on battery type and expected lifespan, check out the Jan. '97 issue of The N&V Solar Workshop. In many cases, you'll have to wire two or more batteries in parallel or series to achieve the 12-volt, 150 Ah goal.

Where did I find these low prices? Most of them were quoted by the sources I listed last month. In case you missed that Workshop, you can download their names and addresses — plus a few new additions — from the Nuts & Volts web site (<http://www.nutsvolts.com>) under the name PVDLRS.TXT.

## Caution! Solar Site Under Construction

According to the clock, we've run out of time for this Workshop because I want to leave room for Mr. Tolson. Next month, I'll describe the hardware needed to wire our power components together. Among the devices discussed will be a UL-rated power center with built-in charge controller, battery monitor, automatic low-battery disconnect, and circuit breakers — plus more. With that said, I'll take my leave so

somebody else can get a word in. Let's put our hands together for Jim Tolson.

## The Classroom

### Jim Tolson's Solar-Powered QRP Shack

Thank you. My name is Jim Tolson, and I'll be your lecturer tonight. Unfortunately, I've never hosted a class before, so bear with me. Let's see ... where should we start? The heart of my station is a Ten-Tec Argonaut 509, with a matching model 405 linear amplifier. I

bought it perhaps 20 years ago in a desire to be environmentally-sensitive by using flea power (or QRP, in ham lingo) for communications with an eye toward hooking up to solar power to run it.

The 509 transceiver puts out a whopping five watts on CW or sideband, and the mighty 405 linear amplifier will boost that to an exhilarating 50 watts when I flip the "POWER" switch. This is awfully low power for some hams, but it lets me get out pretty well. Moreover, it doesn't fry the neighbor's TV sets. So far, I've reached Moscow, Belgium, and Slovenia with a low-slung dipole antenna. I'm still trying to catch Asia, though I suppose Russia counts.

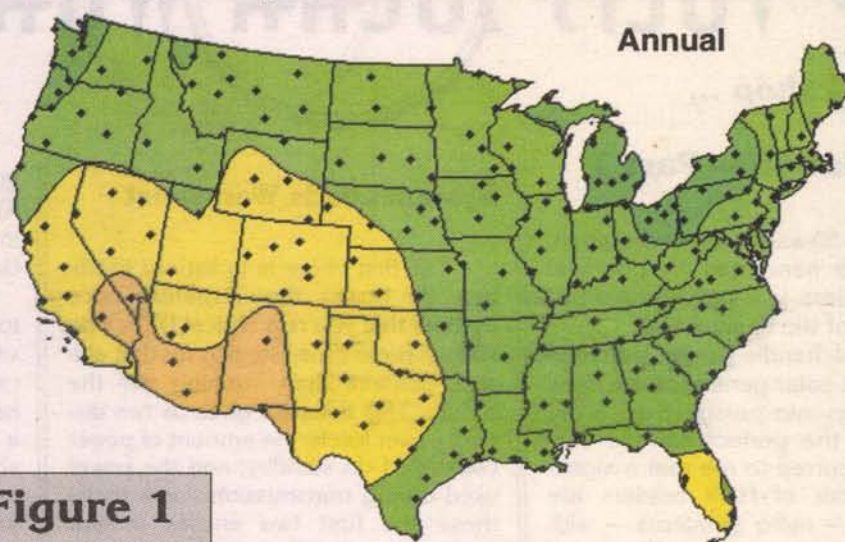
I also have a used Yaesu FT757 transceiver which fits with the rest of my system, but I prefer the analog dial of the old Ten-Tec better. There are QRP enthusiasts who revere the Argonaut, so I consider it a lucky purchase — although these purists probably consider the 50-watt linear amplifier overkill.

I have a nice MFJ 493 keyer, but Morse code is still a challenge for me. So most of my operating is sideband. The nicest toy in the ham shack is a Timewave DSP-9 digital signal processor. This tiny box is wonderful for eliminating background noise, slicing the bandwidth in crowded conditions, and erasing the strong carriers on 40 meters in the evening. I can slide next to a carrier and make it virtually disappear with the DSP box. There's also a small Power Star POW-200 inverter which can fire up a few compact fluorescent bulbs when I want the shack to be completely "off-grid."

All of the above is powered directly by 12 volts DC — which got me to thinking that low-power ham radio is a natural for solar. Nothing "really essential" would be lost if the battery went flat, and the system size isn't too terrifying. Then, of course, I had some Siemen M-55 panels laying around from another project, and I decided to put 'em to good use. Thankfully, I started with just one panel to see how things went. Had I put out all six pan-

## Average Daily Solar Radiation Per Month

Annual



This map is a spatial interpolation of solar values derived from the 1961 - 1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 NSRDB monitoring sites.

### Insolation Value

Orange	6 to 7
Yellow	5 to 6
Light Green	4 to 5
Medium Green	3 to 4
Dark Green	2 to 3

Figure 1

Flat Plate Tilted South at Latitude +15 Degrees

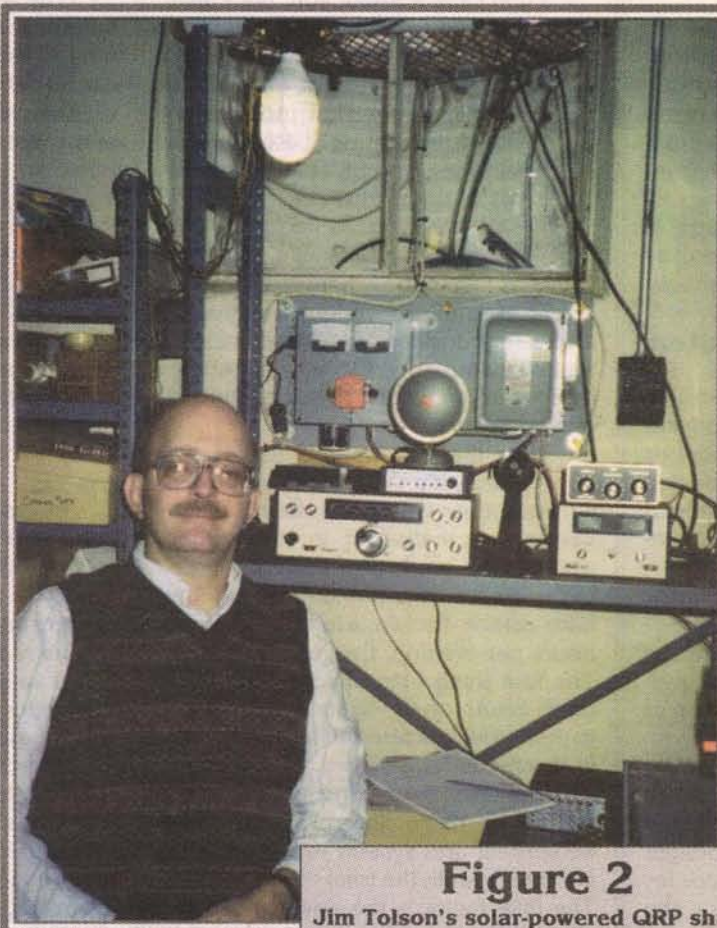


Figure 2

Jim Tolson's solar-powered QRP shack.



# THE NUTS & VOLTS SOLAR WORKSHOP

## Where To Buy

**AAA Solar Service & Supply, Inc.**  
800-245-0311  
<http://www.rt66.com/aaasolar>

**Alternative Energy Engineering**  
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**Sierra Solar Systems**  
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916-265-8441  
800-517-6527 Orders only  
E-Mail: [solarjon@oro.net](mailto:solarjon@oro.net)

**Solar Electric Inc.**  
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San Diego, CA 92109-1602  
800-842-5678  
<http://www.solarelectricinc.com>

**Solarex Corporation**  
630 Solarex Ct.  
Frederick, MD 21703  
301-698-4200  
<http://www.solarex.com/>

**Speciality Concepts, Inc.**  
8954 Mason Ave.  
Chatsworth, CA 91311  
818-998-5238  
<http://www.wp.com/SCINC>

els in the store room, I'd be boiling batteries in a fine fashion!

Backing up the M-55 panel is a 78 Ah gel-cell battery. My system has the capacity for a second M-55 panel and battery if I ever need it, but so far so good. "High power" operation here is 50 watts, which draws a mighty 10 amps from the battery on transmit.

As mentioned, I catch the sun with one Siemens M-55 panel, which I have mounted on the south (front) side of the house. On a bright, sunny day, the Siemens M-55 can crank out 53 watts of power. A few feet of 12-2 USE wire takes the power from the panel, through a hole drilled in the shack's Plexiglas window pane, to the charge controller. A run of #8 wire goes from the panel to a ground stake, and then to the controller. Other holes in the window have bulkhead coax connectors installed for the antenna feeds.

The charge controller is "store bought." I fiddled around with cheap knife switches and skinny wires for a while, and briefly amazed the neighbors with a solar-powered fountain (in a bucket). But after reading articles in *Home Power* magazine about safety code considerations, I realized that a "real" installation ought to be done in a safe manner. I learned that enough power can be stored up to cause elec-

**Table 4. Photovoltaic Sizing Worksheet**

Description	Value
Weekly amp-hour usage	89 Ah
Average daily amp-hour usage (weekly Ah/7)	13 Ah
Insolation factor (from Figure 1)	5.0
Photovoltaic output current (average daily Ah/insolation)	2.6A
Average daily wattage usage (PV output current x 14.2V)	37W
System losses (battery, wire, seasonal, weather, etc.)	13W
About 35% of average daily watts	
Photovoltaic array wattage (average daily watts + losses)	50W

trical fires or injury if the installation is merely done with bell wire and good intentions!

So, I called Real Goods' branch in Amherst, WI, and talked it over with Bob Ramlow, who I'd met at the Midwest Renewable Energy Fair, which is held every year during the Summer Solstice in Amherst. (I recommend this as a great get-together for midwesterners with solar curiosity.) Bob and I talked over safety, practicality, system size, and eventually came up with the following solution (Figure 3).

Central to the system is a wall-mounted control box that includes a voltmeter for monitoring the battery's charge, plus an ammeter to measure incoming current from the photovoltaic panel (which is usually pretty low, unless I've done an awful lot of operating the night before). Real Goods built the box for me according to my needs, which includes leaving space for my Bobier M16 charge controller.

There's even room enough for a second panel should I decide to add on to the system.

On the side of the box are two cigarette lighter outlets, with small fuses, for incidental feeds, like the small inverter I use to power the fluorescent desk lamp when I truly want to go off-line. But the main output is via a

10-foot run of red and black #10 wires to the actual equipment. The 78 amp-hour gel-cell sits below in a battery box, connected to the hot side of the disconnect with #8 wire. The main control box also has a toggle switch to disconnect the M-55 from the system, which can prevent some surprises on a sunny day if I want to fiddle with its innards.

At the time, I thought this battery was pretty big! But then I went up to the aforementioned solar fair and learned it was actually pretty small. Then again, I'm not powering a whole household with this set-up.

The most important parts of this set-up are the ones I would have neglected, for example, a large disconnect switch for the battery feed, with a 30-amp fuse, and a lightning arrestor. Arrestor? But officer ... Bob and his crew do big layouts for whole-house solar, so I'm glad I relied on their expertise to make sure I had a safe and well-designed system.

I usually fire up the rig on weekend afternoons, time permitting. I enjoy fishing out and contacting "Special Event" stations, to collect their certificates (some call these "wallpaper"). Most of these guys pack up as evening approaches out of fatigue, or as the band propagation changes. If I have a project on the

**Table 5. Recommended Photovoltaic Modules**

Manufacturer	Model	Watts	Price	Comments
Kyocera	G51/PV351	51W	\$310-\$325	Multi-crystal
Siemens	M65	45W	\$295	Single-crystal
Siemens	M75	48W	\$319	Single-crystal
Siemens	M55	53W	\$325-\$365	Single-crystal
Solarex	MSX-50	50W	\$340	Semi-crystal
Solarex	MSX-50A	50W	\$335	Semi-crystal
Solarex	PV253	53W	\$295	Economy model
Solarex	VLX-53	53W	\$284-\$320	Polycrystal
Solec	S-55	55W	\$300-\$350	Single-crystal

**Table 6. Recommended Batteries**

Manufacturer	Model	Voltage	Capacity	Weight	Price	Comments
Deka	8G27	12V	86 Ah	64 lbs	\$150-\$180	Sealed/\$340
Deka	8G4D	12V	180 Ah	135 lbs	\$259-\$390	Sealed/\$300
Exide	SP-27	12V	90 Ah	59 lbs	\$132	Gel-cell/\$264
Exide	GC-4	6V	186 Ah	61 lbs	\$70	Flooded/\$140
GNB	Sunlyte 12-5000	12V	90 Ah	59 lbs	\$170-\$210	AGM/400
Lifeline	Group 24	12V	80 Ah	53 lbs		AGM
Optima	Optima 800	12V	56 Ah	40 lbs		AGM
Power Sonic	PS-12800	12V	80 Ah	62 lbs	\$147	Sealed/\$294
Rolls Batteries	24-90-XJ	12V	90 Ah	50 lbs		Flooded
Rolls Batteries	12XH-165	12V	165 Ah	126 lbs		Flooded
Generic	Type 27	12V	86 Ah	64 lbs	\$100+	Flooded
Generic	Type 4D	12V	180 Ah	135 lbs	\$225+	Flooded

## HOT! Photovoltaic Web Sites

**CREST, the Center for Renewable Energy and Sustainable Technology** (<http://solstice.crest.org/>) is specifically geared to providing info via the Internet, and includes a good database of US climate data, including detailed solar data on hundreds of cities (Figure 3).

**The Solar and Renewable Energy Resources list** (<http://www.ises.org/pages/solarinfo.html>), maintained by the International Solar Energy Society, is the most comprehensive solar Website I've ever seen. **This is a must — check it out.**

**The National Renewable Energy Laboratory's Web site** (<http://www.nrel.gov/research/pv/tapsun.html>) includes a comprehensive discussion of the economics of photovoltaics and descriptions of a range of applications.

**The US Department of Energy's "Energy Efficiency & Renewable Energy Network"** (<http://www.eren.doe.gov/>) is a good general source on efficiency and renewable energy, and includes a range of databases.

Continued on page 80



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TEK 7844 400 MHz Dual Beam Oscilloscope frame	\$750.00
TEK 7844 .400 MHz Dual Trace Oscilloscope	\$1,250.00
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TEK 7854 400 MHz Waveform Processing Oscilloscope frame	\$1,250.00
TEK 7904A .500 MHz System, with 7A24, 7A26, 7B92A	\$1,250.00
TEK 7904A .500 MHz System, with 7A24, 7A26, 7B80, 7B85	\$1,250.00
TEK 7A13 105 MHz Differential Comparator	\$300.00
TEK 7A19 600 MHz Single Trace Amplifier	\$175.00
TEK 7A19-opt.4 600 MHz Single Trace Amplifier, variable delay line	\$200.00
TEK 7A24 400 MHz Dual Trace Amplifier	\$350.00
TEK 7A26 200 MHz Dual Trace Amplifier	\$175.00
TEK 7A29 1 GHz Single Trace Amplifier	\$550.00
TEK 7A29-opt.04 1 GHz Single Trace Amplifier, variable delay line	\$650.00
TEK 7B15 1 GHz Delaying Time Base	\$450.00
TEK 7B80 400 MHz Delayed Time Base	\$175.00
TEK 7B85 400 MHz Delta Delaying Time Base	\$200.00

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TEK 7633 100 MHz Storage Oscilloscope frame	\$650.00
TEK 7633 .100 MHz Storage Oscilloscope with (2) 7A26, (1) 7B92A	\$1,000.00

### PROBES

TEK 1101 Accessory Power Supply, for FET probes	\$250.00
TEK P6046 100 MHz Differential Probe	\$750.00
TEK P6101A 34 MHz 1X Modular Probe, 2m length "NEW"	\$25.00
TEK P6108A 100 MHz 10X Modular Probe, 2m length "NEW"	\$50.00
TEK P6201 900 MHz 1X/10X/100X FET Probe	\$450.00
TEK P6202A 500 MHz 10X FET Probe	\$300.00
TEK P6203 10X 1 GHz Active Probe, for 11000 series	\$450.00
TEK P6701-opt.02 O/E Converter, 450-1050 nm/0-1 mW: DC-700 MHz, ST conn.	\$675.00

### CALIBRATION

TEK CG5001-opt.01/TM5006	\$7,000.00
Programmable Oscilloscope Calibrator, with power module	
TEK CG551AP/TM506A Oscilloscope	\$3,500.00
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TEK FG502 11 MHz Function Generator, TM500 series	\$325.00
TEK FG503 3 MHz Function Generator, TM500 series	\$275.00
TEK RG501 Ramp Generator, TM500 series	\$225.00
WAVETEK 23 12 MHz Synthesized Function Generator	\$1,100.00

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HP 214B-001 10 MHz Pulse Generator, 50 V/50 ohms, counted burst opt	\$2,000.00
HP 8005B 20 MHz Dual Output Pulse Generator	\$450.00
HP 8007B 100 MHz Pulse Generator	\$650.00
HP 8012B 50 MHz Pulse Generator, variable transition time	\$600.00
HP 8013B 50 MHz Dual Output Pulse Generator, 3.5 nS fixed Tr	\$600.00
HP 8015A 50 MHz Dual Output Pulse Generator	\$700.00
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HP 8082A 250 MHz Dual Output Pulse Generator	\$1,400.00
PHILIPS PM5785B 125 MHz Dual Output Pulse Gen., burst mode, 1 nS Tr	\$875.00
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HP 3325A-002 Synth./Function Gen., 1 uHz-21 MHz, 40V out 1 uHz-1 MHz	\$2,400.00
HP 8160A 50 MHz Programmable Pulse Generator, HP1B	\$2,500.00
HP 8165A-002,003 Prog. Signal Source, 1 mHz-50 MHz, log sweep, rear out	\$2,000.00
TEK AWG5102 Arb.Waveform Gen., 20 MS/s, 12 bits, 50ppm synthesis <1MHz	\$1,400.00
TEK AWG5105 Arbitrary Waveform Generator, 50 MS/s, 12 bits	\$1,700.00
TEK AWG5105-opt.02 Arbitrary Waveform Generator, dual channel option	\$2,200.00

TEK FG5010 Programmable 20 MHz Function Generator, TM5000 series	\$1,200.00
WAVETEK 288 20 MHz Synthesized Function Generator, GPIB	\$1,500.00

## VOLTAGE & CURRENT

### VOLTMETERS

HP 3456A 6-1/2 Digit Voltmeter	\$850.00
KEITHLEY 181 6-1/2 digit Nanovoltmeter, 10 nV sensitivity, GPIB	\$1,500.00
SOLARTRON 7081 8-1/2 digit Voltmeter	\$3,900.00
SOLARTRON 7150 5-1/2 digit Multimeter, GPIB	\$450.00

### CALIBRATION

FLUKE 332B/AF DC Voltage Calibrator, 0-1111 V, 0-50 mA, 7 decades	\$675.00
FLUKE 343A DC Voltage Calibrator, 0-1100 V, 7 decades, 20 ppm acc.	\$1,375.00
FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA	\$450.00
FLUKE 515A Portable Calibrator, DC/AC/Ohms, line & battery power	\$1,250.00
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A	\$3,750.00
FLUKE 720A Kelvin-Voltage Divider, 7 decade	\$2,250.00
FLUKE 731B DC Reference Standard	\$400.00
FLUKE A55-series AC Thermal Converters	\$300.00
HP 11049A AC Thermal Converter, 3 V, 20 Hz-100 MHz	\$175.00
VALHALLA 2703 AC Volt.Stid., 0-120V/10 Hz-100 kHz; 120-1200V/10 Hz-1 kHz	\$2,500.00

### VOLTAGE SOURCES

HP 6114A Precision Dual Range Power Supply, 20 V 2 A / 40 V 1 A	\$875.00
HP 6115A Precision Dual Range Power Supply, 50V 0.8A / 100V 0.4A	\$875.00

### CURRENT METERS & SOURCES

DRANETZ 656A / (3)TR2019A Current Demand Analyzer, w/(3) current probes 300A max.	\$5,000.00
HP 4140B Picoammeter / DCV Source	\$4,000.00
HP 6177C DC Current Source, to 50V, 500mA	\$600.00
HP 6181C DC Current Source, to 100 V, 250 mA	\$675.00
HP 6186C DC Current Source, to 300V, 100mA	\$750.00
KEITHLEY 414A Picoammeter, 0.1 nA-10 mA	\$325.00
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TEK CT-5 -opt.05 High Current Transformer for P6021/A6302, to 1000A	\$500.00
VALHALLA 2301 Programmable Single Phase Power Analyzer	\$1,250.00
VALHALLA 2575A AC/DC Active Current Shunt, 20 mA-100 A, DC-10 kHz	\$1,000.00

## IMPEDANCE & COMPONENT TEST

### L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH	\$550.00
HP 4261A 3-1/2 digit LCR Meter, 120 Hz/1 kHz	\$1,000.00
HP 4262A-101 4-1/2 digit LCR Meter, 120 Hz/1 kHz/10 kHz, HP1B	\$2,200.00
HP 4275A-001 5-1/2 digit LCR Meter, 10 kHz-10 MHz, 0-35 V int. bias	\$6,000.00

### STANDARDS

E.S.I. SR1010 Resistance Transfer Standards, 1 ohm-100 K/step	\$700.00
E.S.I. SR1050-10M Resistance Transfer Standard, 10 Megohms/step	\$2,500.00
GR 1403-SERIES Standard Air Capacitors, 0.1% accuracy	\$150.00
GR 1406 Standard Air Capacitors, GR900 connector, 0.1% acc.	\$375.00
GR 1409-SERIES Standard Mica Capacitors, 0.05% accuracy	\$150.00
GR 1412-BC Decade Capacitor, 50 pF - 1.11115 uF	\$350.00
GR 1432-N 5-Decade Resistor, to 11,111 ohms, 0.1 ohm res.	\$175.00
GR 1432-U 4-Decade Resistor, 0-111.10 ohms, 0.01 ohm resolution	\$125.00
GR 1433-J 4-Decade Resistor, 0-1,110 ohms, 1 ohm resolution	\$350.00
GR 1433-L 4-Decade Resistor, 0-11,110 ohms, 10 ohm resolution	\$350.00
GR 1433-N 5-Decade Resistor, 0-11,111 ohms, 0.1 ohm resolution	\$400.00
GR 1433-Q 4-Decade Resistor, 0-1,111,000 ohm, 100 ohm resolution	\$350.00
GR 1433-U 4-Decade Resistor, 0-111.0 ohms, 0.01 ohm resolution	\$350.00
GR 1433-W 6-Decade Resistor, 0-11,111.1 ohms, 0.01 ohm resolution	\$450.00
GR 1433-X 6-Decade Resistor, to 111,111.0 ohms, 0.1 ohm res.	\$450.00
GR 1434-G 7-Decade Resistor, 0-1,111,111.0 ohms, 0.1 ohm res.	\$300.00
VALHALLA 2724A Programmable Resistance Standard, 0-11 Gigaohms, GPIB	\$1,675.00

### HI & LO RESISTANCE

HP 4329A High Resistance Meter, 5E5-2E16 Ohms, 10-1000 V test	\$1,350.00
VALHALLA 4150-ATC 4-1/2 digit Ohmmeter, 20 milliohms-2 kilohms, 4-wire	\$1,000.00

### CURVE TRACERS

TEK 577D1/177 Storage Curve Tracer, with standard test fixture	\$2,250.00
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### T.D.R.

TEK 1503-opt.04 Time Domain Reflectometer, 0-50,000 feet, chart recorder	\$1,600.00
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## POWER SUPPLIES

### SINGLE OUTPUT

HP 6200B Dual Range Power Supply, 20 V 1.5 A / 40 V 0.75 A CV/CC	\$250.00
HP 6201B 20 V at 1.5A CV/CC Power Supply	\$200.00
HP 6206B Dual Range 0-60 V 0.5 A / 0-30 V 1 A CV/CL Supply	\$250.00
HP 6207B 160 V at 200 mA CV/CC Power Supply	\$300.00
HP 6209B 320 V at 100 mA CV/CC Power Supply	\$300.00
HP 6260B-027 10V at 100A CV/CC Power Supply	\$675.00
HP 6261B-027 20 V at 50 A CV/CC Power Supply	\$675.00
HP 6263B 20 V at 10 A CV/CC Power Supply	\$400.00
HP 6268B 40 V at 5 A CV/CC Power Supply	\$400.00
HP 6268B-027 40 V at 30 A CV/CC Power Supply	\$850.00
HP 6299A 100 V at 750 mA CV/CC Power Supply	\$250.00
HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply	\$175.00
HP/HARRISON 6443B 120 V at 2.5 A CV/CC Power Supply	\$400.00
LAMBDA LES-EE-03-OV 36 V at 14.5 A CV/CC	\$500.00
Power Supply, LED metered	
SORENSEN DCR 110-45T 110 V at 45 A CV/CC Power Supply	\$2,200.00
SORENSEN DCR 300-6B 300 V at 6 A CV/CC	\$950.00
Power Supply, 120 VAC 30 A line	
SORENSEN DCR 300-8A 300 V at 8 A CV/CC	\$950.00
Power Supply, 208/230 VAC line	
SORENSEN SRL 20-12 20 V at 12 A CV/CC	\$550.00
Power Supply, low noise	
SORENSEN SRL 60-8 60 V at 8 A CV/CC	\$950.00
Power Supply, low noise	
TEK PS501-1 Power Supply, 0-20 V, 2 mV res., 400 mA, TM500 series	\$175.00

### MULTIPLE OUTPUT

HP 6227B Dual 25 V at 2 A CV/CC Power Supply, tracking	\$550.00
HP 6243A Dual Output 20 V 3 A CV/CC Power Supply	\$500.00
HP 6255A Dual Output 40 V 1.5 A CV/CC Power Supply	\$500.00
TEK PS5010 Programmable Triple Power Supply, TM5000 series	\$800.00

### MISCELLANEOUS

HP 59501A HP1B Isolated DAC/Power Supply Programmer	\$175.00
HP 6827A Bipolar Power Supply/Amplifier, to 100 V, 500 mA	\$800.00
KEPCO BOP 100-4M Bipolar Supply / Amplifier, 0-100 V, 0-4 A	\$1,000.00
TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max.	\$200.00

## TIME & FREQUENCY

### UNIVERSAL COUNTERS

HP 5315A-001 100 MHz/100 nS Universal Counter, TCXO reference	\$650.00
HP 5315A-001,003 100 MHz/100 nS Universal Counter, TCXO, 1 GHz C-channel	\$800.00
HP 5316A 100 MHz/100 nS Universal Counter, HP1B	\$750.00
HP 5316A-003,006 100 MHz/100 nS Counter, 1 GHz C-ch., offset/normalize	\$1,100.00
HP 5334A 100 MHz Universal Counter, HP1B	\$875.00
HP 5334B-010,060 100 MHz Universal Counter, HP1B, OCXO	\$1,000.00
HP 5335A 200 MHz Universal / Statistical Counter	\$1,500.00
HP E1420A-010,030 VXI card 200 MHz/2 nS Univ. Counter, TCXO & 2.5 GHz C-ch	\$900.00
RACAL-DANA 1992-04,55 100 MHz/1 nS Univ. Counter, 1.3 GHz C-channel, OCXO, GPIB	\$850.00
TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series	\$350.00
TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series	\$600.00
TEK DC503A 125 MHz Universal Counter/Timer, TM500 series	\$450.00

### FREQUENCY COUNTERS

EIP 575 18 GHz Source Locking Counter, GPIB	\$3,250.00
EIP 590-opt.92 WR19 Mixer Kit, 40-60 GHz, for EIP option 06 counters	\$875.00
FLUKE 7220A-opt.111 1.3 GHz Communications Counter, TCXO option	\$650.00
HP 5340A-001,011 18 GHz Frequency Counter, OCXO reference, HP1B	\$1,900.00
HP 5340A-005,011 23 GHz Frequency Counter, HP1B	\$2,000.00
HP 5342A 18 GHz Frequency Counter	\$2,400.00
HP 5342A-003,011 18 GHz Freq. Counter, +22 dBm, -20 dBm dynamic range, HP1B	\$2,750.00
HP 5342A-01,04,05,11 24 GHz Frequency Counter, OCXO, DAC, and HP1B	\$3,900.00
HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter	\$4,000.00
HP 5382A 225 MHz Frequency Counter	\$200.00

### STANDARDS

AUSTRON 1250A Crystal Frequency Standard, 0.1/1.0/ 5.0 MHz	\$600.00
HP 105A Quartz Oscillator, 0.1/1.0/ 5.0 MHz	\$750.00





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## AUDIO & BASEBAND

### SPECTRUM ANALYZERS

HP 8556A LF Section, 20 Hz-300 kHz	\$450.00
TEK 7L5-opt.025/L3-1 Spectrum Analyzer, 20 Hz-5 MHz, 75 / 600 / 1M ohms	\$2,250.00

### DISTORTION ANALYZERS

HP 334A Distortion Analyzer, 5 Hz-600 kHz, -60 dB, auto nulling	\$550.00
HP 339A Distortion Analyzer, built-in low distortion osc.	\$2,200.00

### RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, 180 uV-700 V, 10 Hz-20 MHz	\$700.00
FLUKE 8921A True RMS Voltmeter, 180 uV-700 V, 2 Hz-2 MHz	\$700.00

### OSCILLATORS

HP 204C Oscillator, 5 Hz-1.2 MHz, 5 VRMS	\$150.00
HP 204D Oscillator, 5 Hz-1.2 MHz, 5 VRMS, 80 dB step attenuator	\$200.00
HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5 VRMS max.	\$225.00
HP 239A Low Distortion Oscillator, 10 Hz-100 kHz	\$450.00
HP 652A Test Oscillator, 10 Hz-10 MHz	\$300.00
TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten., TM500	\$200.00

### MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display	\$900.00
HP 4437A Step Attenuator, 0-119.9 dB, DC-1 MHz, 600 ohms unbal.	\$200.00
KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave	\$500.00
KROHN-HITE 3202 Dual High-Pass/Low-Pass Filter, 20 Hz-2 MHz, 24 dB/oct	\$600.00
KROHN-HITE 3342 Dual HP/LP Filter, 0.001 Hz-99.9 kHz, 48 dB/octave	\$1,100.00
KROHN-HITE 3750 LP/HP/BP/BR Filter, 0.02 Hz-20 kHz, 6/12/18/24 dB/oct.	\$700.00
ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz	\$1,000.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	\$475.00

## RF & MICROWAVE

### SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer, 12.4-40 GHz, w/adapters, for 8555A, 8565A, etc.	\$675.00
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz	\$1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz	\$1,400.00
HP 11970U WR19 Harmonic Mixer, 40-60 GHz	\$1,400.00
HP 11971A WR28 Harmonic Mixer, 26.5-40.0 GHz, for 8569B	\$1,100.00
HP 11971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 8569B	\$1,100.00
HP 8406A Comb Generator, 1/10/100 MHz increments, to 5 GHz	\$450.00
HP 8444A-059 Tracking Generator, 0.5-1500 MHz, for 8554, 8568, etc.	\$1,500.00
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A	\$650.00
HP 8557A/182T Spectrum Analyzer, 0.01-350 kHz, 1 kHz res., w/display	\$1,650.00
HP 8565A-100 Spectrum Analyzer, 0.01-22 GHz, 100 Hz min. res. BW	\$5,500.00
TEK 7L13/7633 Spectrum Analyzer, 1 kHz-1.8 GHz, 30 Hz min.res., w/frame	\$2,250.00
TEK TR502 Tracking Generator, 0.1-1800 MHz, for 7L12/13/14	\$1,250.00
TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6	\$1,375.00

### NETWORK ANALYZERS

HP 11589A Bias Network, 0.1-3.0 GHz, N(f/f)	\$350.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7	\$450.00
HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7	\$375.00
HP 11666A Reflectometer Bridge, 0.04-18 GHz, for 8755/8756	\$1,200.00
HP 85050D APC7 Calibration Kit, for 8510 series	\$1,100.00
HP 8505A-005/8503A Network An., 0.5-1300 MHz, w/S-Parameter & phase lock	\$5,000.00
HP 8755C/(3)11664A/182T Scalar Network An. w/3 detectors, 10 MHz-18 GHz & frame	\$1,750.00
HP 8756A/(3)11664A Scalar Network Analyzer, w/(3) detectors, 0.01-18 GHz	\$3,750.00
NARDA 7000A/7202/7206 Microwave Multimeter System: scalar analysis 0.1-18 GHz	\$1,950.00
WAVETEK 1038D14A/H12V13x2 Scalar Network An., w/(3)15882 WR28 detectors, 26.5-40 GHz	\$2,200.00

### SIGNAL GENERATORS

FLUKE 6060A/AN Synthesized Signal Gen., 10 kHz-520 MHz, 10 Hz res, GPIB	\$2,000.00
GIGATRONICS 600/10-18 Synthesized Source, 10-18 GHz, 1 MHz res., GPIB	\$2,600.00
GIGATRONICS 605/10-18 Synthesized Source, 10-18 GHz, 1 kHz res., GPIB	\$3,000.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm	\$3,500.00
GIGATRONICS 875/86 Levelled Multiplier, 26.5-40.0 & 50.0-75.0 GHz outputs	\$7,000.00
GIGATRONICS 910/12-18, opt6, 14, 16 Synthesized Source/Sweeper, 12-18 GHz, 1 Hz res., OXCO	\$3,500.00
HP 85100V Frequency Mult., 10-15 GHz in / 50-75 GHz out >0 dBm	\$4,250.00
HP 8616A Signal Generator, 1.8-4.5 GHz	\$450.00
HP 8640B-001,002,003 Signal Gen., 0.5-1024 MHz, AM, FM, var. audio osc.	\$2,500.00
HP 8654A Signal Generator, 10-520 MHz, calibrated AM & uncal. FM	\$550.00
HP 8656A Signal Generator, 0.1-990 MHz, 100 Hz res, AM, FM, GPIB	\$2,900.00
HP 8660C/86602B/86632A Synthesized Signal Gen., 1-1300 MHz, 1 Hz res., AM, FM	\$2,750.00

HP 8660D/86603A/86632B Synthesized Signal Generator, 1-2600 MHz	\$7,000.00
HP 8671A-005 Synthesized CW Generator, 2.0-6.2 GHz, 1 kHz res., GPIB	\$6,000.00

### SWEEP GENERATORS

HP 11869A Plug-in Adapter	\$450.00
HP 8350A/86290B-H08 Programmable Sweep System, 2.0-22.0 GHz, +4 dBm m'd	\$5,500.00
HP 8600A Digital Marker, for HP 8601A	\$400.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	\$400.00
HP 8620C Sweep Oscillator Frame	\$550.00
HP 8620C-011 Sweep Oscillator Frame, GPIB programmable	\$675.00
HP 86222B-002 RF Plug-in, 10-2400 MHz, +10 dBm levelled, step atten.	\$1,750.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	\$675.00
HP 86240A RF Plug-in, 2.0-8.4 GHz, +16 dBm levelled	\$1,000.00
HP 86240A-002 RF Plug-in, 2.0-8.4 GHz, +14 dBm lvid., 70 dB step att.	\$1,200.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	\$500.00
HP 86242D-004,008 RF Plug-In, 5.9-9.0 GHz, +10 dBm levelled	\$500.00
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled	\$1,100.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled	\$675.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled	\$800.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled	\$800.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled	\$1,750.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled	\$2,250.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled	\$2,500.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unlvld.	\$2,000.00

### POWER METERS

ANRITSU MP-81B/ML-83A Power Meter, 75-110 GHz (WR10), -20 to +20 dBm	\$2,500.00
ANRITSU MP-82B/ML-83A Power Meter, 90-140 GHz (WR8), -20 to +20 dBm	\$3,250.00
BOONTON 42B/41-4B Analog Power Meter, with 1 MHz-12 GHz sensor	\$375.00
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	\$500.00
GENERAL MICROWAVE 476/4240A Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm	\$375.00
HP 432A/478A Power Meter, 10 MHz-10 GHz, -20 to +10 dBm f.s.	\$375.00
HP 432A/8478B Power Meter, 10 MHz-18 GHz, -20 to +10 dBm f.s.	\$500.00
HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s.	\$425.00
HP 435A/8481A Power Meter, 10 MHz-18 GHz, -30 to +20 dBm	\$1,000.00
HP 435A/8482A Power Meter, 100 kHz-4.2 GHz, -30 to +20 dBm	\$1,000.00
HP 435A/8482H Power Meter, 0.1-4200 MHz, -15 to +34 dBm	\$1,150.00
HP K486A WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 series	\$350.00
HP Q8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8	\$1,500.00
HP R486A WR28 Thermistor Mount, 26.5-40.0 GHz, for 432 series	\$350.00

### RF MILLIVOLTMETERS

RACAL 9303 TRMS Level Meter, 10 kHz-2 GHz, -77 to +23 dBm, GPIB	\$875.00
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### AMPLIFIERS, MISCELLANEOUS

BOONTON 82AD FM/AM Modulation Meter, 10-1200 MHz	\$800.00
HP 8447A-001 Dual Amplifier, 0.1-400 MHz	\$450.00
HP 8901A-002,010 Modulation Analyzer, 150 kHz-1300 MHz, OXCO, int. cal.	\$5,500.00
M.P.D. LAB2-1020-2A Amplifier, 34 dB, 1.0-2.0 GHz, 2 Watts	\$800.00
M.P.D. LAB2-714-3A Amplifier, 34 dB, 0.7-1.4 GHz, 3 Watts	\$800.00
MARCONI TF2304 AM/FM Modulation Meter, 18-1000 MHz, FM dev.1.5-150 kHz	\$500.00
MICROWAVE SEMI.CORP. MC5112 Noise Source, 25.5 dB ENR, 1.0-12.4 GHz, N(m), +28 VDC	\$325.00

## COAXIAL & WAVEGUIDE

AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz, TNC(f) "NEW"	\$95.00
CONTINENTAL MW.&TOOL PLPT42 WR42 Low Power Termination, 18-26.5 GHz, 1 Watt	\$125.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 200-1000 MHz, 100 Watts max., N(m/f)	\$90.00
GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz	\$450.00
GR 900-Q GR900 14mm Interseries Adapters	\$125.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz	\$450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz	\$800.00
HP 3330B Crystal Detector, 0.01-18 GHz, neg. pol., SMA(m)/SMC(f)	\$135.00
HP 774D Dual Directional Coupler, 20 dB, 200-500 MHz	\$275.00
HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz	\$275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz	\$275.00
HP 778D Dual Dir.Coupler, 20 dB, 100-2000 MHz, N(m/f)/f	\$550.00
HP 778D-011 Dual Dir.Coupler, 20 dB, 100-2000 MHz, APC7/N(f)/f	\$400.00
HP 8470B-012 Crystal Detector, 10 MHz-18 GHz, neg. pol., N(m)	\$250.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz	\$350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz	\$500.00
HP K752 A/C/D WR42 Directional Couplers, 3/10/20 dB, 18.0-26.5 GHz	\$450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz	\$275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz	\$425.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz	\$650.00
HP R375A WR28 Variable Attenuator, 0-20 dB, 26.5-40 GHz	\$375.00

HP R422A WR28 Flat Broadband Detector, 26.5-40 GHz	\$400.00
HP R532A WR28 Frequency Meter, 26.5-40.0 GHz	\$500.00
HP R914B WR28 Moving Load, 26.5-40 GHz	\$300.00
HP X913A WR90 High Power Load, 500 Watts, 8.2-12.4 GHz	\$150.00
HUGHES 45111H-2000 WR28 Isolator, 25 dB, 26.5-40 GHz	\$450.00
HUGHES 45113H-1000 WR19 Isolator, 25 dB, 40-60 GHz	\$650.00
HUGHES 45514H-1001 WR15 Stepper Motor Driven 4-Port Switch, with driver	\$1,675.00
HUGHES 45521H-2000 WR28 Manual 4-Position Switch	\$750.00
HUGHES 45713H-1000 WR19 Frequency Meter, 40-60 GHz	\$900.00
HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity	\$750.00
HUGHES 47323H-1211 WR19 Flat Broadband Detector, negative, 40-60 GHz	\$650.00
HUGHES 47974H-1000 WR15 SPST PIN Switch, 250 MHz speed, 60-62 GHz response	\$375.00
KRYTAR 1818 Directional Coupler, 16 dB, 2-18 GHz, SMA(f)	\$200.00
M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz	\$450.00
MINI-CIRCUITS ZFDC-20-4 Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f)	\$25.00
NARDA 25171 Level Set Attenuator, 0-17 dB, 2-8 GHz, SMA(f)	\$100.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(f/f)	\$200.00
NARDA 3000-SERIES Directional Couplers	\$150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz	\$300.00
NARDA 3090-SERIES Precision High Directivity Couplers	\$225.00
NARDA 368NM Coaxial High Power Load, 500 Watts, 2.0-12.4 GHz, N(m)	\$400.00
NARDA 369BNF High Power Termination, 175 Watts, 0.7-18 GHz, N(f)	\$325.00
NARDA 3753B Coaxial Phase Shifter, 0-60 deg./GHz, 3.5-12.4 GHz	\$1,250.00
NARDA 4000-SERIES SMA Miniature Directional Couplers	\$75.00
NARDA 4203-6 Directional Coupler, 6 dB, 2-18 GHz, SMA(f)/f	\$225.00
NARDA 4246B-20 Directional Coupler, 20 dB, 6-18 GHz, SMA(f)	\$100.00
NARDA 4317-2 Power Divider, 18.0-26.5 GHz, 3.5mm	\$175.00
NARDA 4799 Level Set Attenuator, 0-15 dB, 4-18 GHz, SMA(f)	\$135.00
NARDA 5070-SERIES Precision Reflectometer Couplers	\$300.00
NARDA 765-20 20 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f)	\$135.00
NARDA 766-10 10 dB Attenuator, 20 Watts, DC-4 GHz, N(m/f)	\$100.00
NARDA 768-20 20 dB Attenuator, 20 Watts, DC-11 GHz, N(m/f)	\$125.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz	\$375.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz	\$250.00
SIERRA 662A-20 20 dB Attenuator, 100 Watts, N(f/f)	\$150.00
SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz	\$125.00
SPACE LABS DQ-1 WR22 Flat Broadband Detector, 33-50 GHz	\$550.00
TELEONIC TTF-2250-5-SEE Tuneable Bandpass Filter, 1.5-3.0 GHz, 5% 3 dB BW, N(f)	\$350.00
TRG V510 WR15 Precision Rotary Vane Atten., 0-50 dB, 50-75 GHz	\$1,000.00
TRG V551 WR15 Frequency Meter, 50-75 GHz	\$600.00
TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz	\$400.00
TRG W510 WR10 Precision Rotary Vane Atten., 0-50 dB, 75-110 GHz	\$1,000.00
TRG W559-10 WR10 Directional Coupler, 10 dB, 75-110 GHz	\$475.00
WAVELINE 822 WR42 Precision Rotary Vane Atten., 0-50 dB, 18-26.5 GHz	\$1,250.00
WAVELINE 898-DR WR42 Frequency Meter, 18.0-26.5 GHz	\$350.00
WEINSCHTEL 1515 Power Divider, 2-Way, DC-18 GHz, SMA(m/f/f)	\$125.00
WEINSCHTEL 49-6-34 6 dB Attenuator, 150 Watts, DC-8 GHz, N(f/m)	\$250.00
WILTRON 26N50 Precision Termination, N(m), DC-18 GHz	\$250.00
WILTRON 60N50-opt.1 SWR Bridge, 5-2000 MHz, 46 dB directivity, N(m/f/f)	\$500.00
WILTRON 87A50 VSWR Bridge, 2-18 GHz, 35 dB dir., APC7 test port	\$600.00

## LOGIC

FLUKE 9000A-series Microprocessor Pods: 6800; 6809; 8080; 8085; Z80	\$375.00
HP 5005A Signature Multimeter	\$350.00
HP 8170A-002 Logic Pattern Generator, 2 MB/s, address driver option	\$1,200.00
TEK 1240 Logic Analyzer, w/(36) 50 MHz channels	\$1,500.00
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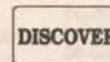
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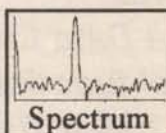
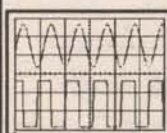
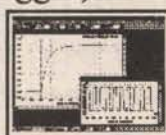
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# Serial Communications and Protocol Stacks:

## Part 1

## Why All The Layers?

**This article explains the concept of layered protocol stacks and provides you with interrupt driven serial communications routines that you can use in your own applications.**

**Part 2 will provide you with a Data Link Layer protocol built from the low-level functions supplied here. The code is written using Turbo C, and supports transfer speeds up to 19.2K.**

Serial programming is complex and requires knowledge of interrupt level programming and your computer's hardware. By using the code, examples, and concepts provided in this article, you will understand the PC's serial port hardware and be well on your way to inventing your own communications protocols.

### Protocol Stacks

Reliable communications protocols are complicated and can be difficult to program. In early networks, most of the design effort went into hardware, and software

computers to effectively communicate with one another, programmers could draw on the unique resources and capabilities of the connected machines, creating a powerful virtual machine.

How was all this complexity to be managed in order to harness the power of a virtual machine? Divide the complexity into clear cut layers of functionality, starting from the most generalized abstraction at the top layer and becoming more and more specific as the bottom layer is approached.

That's the common sense idea behind dividing up computer communications into several layers. A

Each layer in the protocol stack speaks exactly the same language, and can only communicate at the same layer level. This is sometimes called peer-to-peer communication, which is represented by the horizontal lines between the layers in Figure X.

Layer 1 on one machine is exactly like Layer 1 on another machine, Layer 2 is the same as Layer 2, and so on. The services increase in abstraction from the bottom up, all the way up to the top layer. The top layer is usually called the Application Layer. Each Layer, except for the Application Layer, offers clearly defined services to the other layers. The Application Layer only uses services, since there are no more layers above it. The services offered to each of the layers are made available via Service Access Points, or SAPs.

For example, let's say that within a program you call a function named ReadFile(filename) in the Application Layer on Machine 1. Figure 2 illustrates a simple protocol stack used to implement ReadFile(filename).

Assume that the actual file is on

mission media. That's the job of the lower layers.

The Application Layer is the most abstract, with each underlying layer becoming less and less abstract and more concerned with the actual work of transmitting and receiving the file. This is the idea behind Client/Server applications. The Application Layer on Machine 1 is the Client. It just wants file information, and doesn't care where it gets it from. The Server responds to the ReadFile(filename) function call and provides the file data.

In our model, we have four layers. The Application Layer is the highest level and does not provide any services to other layers. Next is the Transport Layer. The Transport Layer's responsibility is to provide reliable services to the Application Layer. It will take the file data, which is usually very large, and break it into smaller numbered segments to prepare it for transmission, as shown in Figure 3.

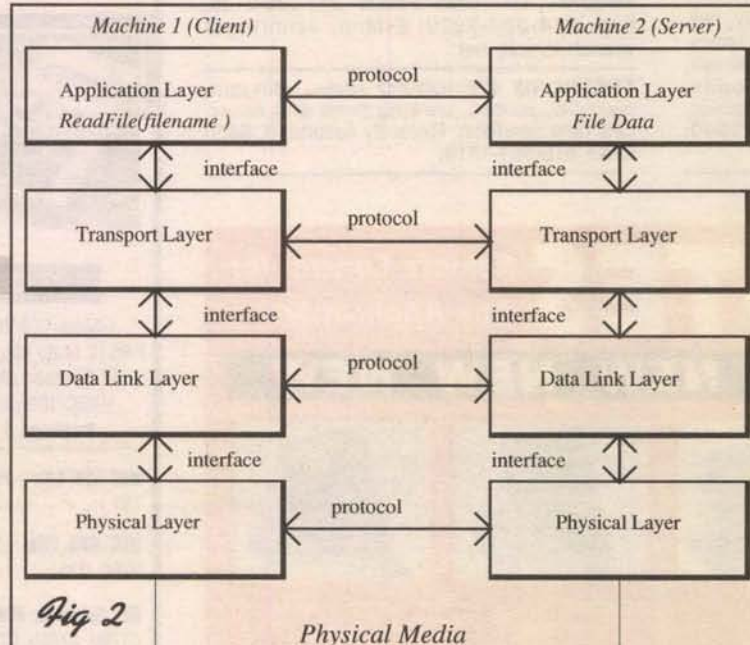
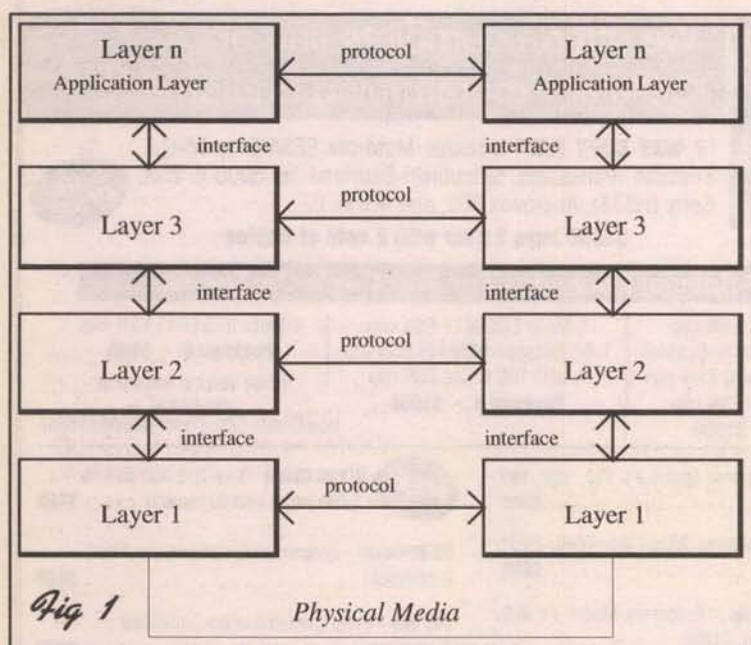
The Transport Layers on both machines understand that the file data will be received in enumerated segments, then will re-assemble the data segments back into a continuous file, in the proper

order. The Transport Layer must ensure that the data is assembled in the right order.

Some of you familiar with the OSI and TCP/IP stacks may wonder why there is no Network Layer present. This article focuses on single machine-to-machine communications. There is no network to deal with.

The next layer in our model is the Data Link Layer. The Data Link Layer takes the raw input data stream from the Physical Layer if receiving, or takes fragmented data from the Transport Layer if sending, and breaks it up into frames.

Data Link Layer frames typically are partitioned into two or three parts. The leading part of the frame is the header, the middle is the payload data, and the trailer is the frame's checksum or CRC (Cyclic Redundancy Check). The header contains different fields such as the frame's sequence number, the length of the frame, and an



was thought of as the easy or trivial part. Nowadays, hardware is (unfairly?) considered the easy element and software is definitely the complicated part.

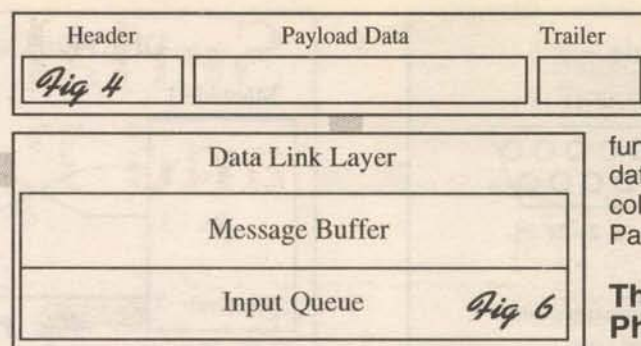
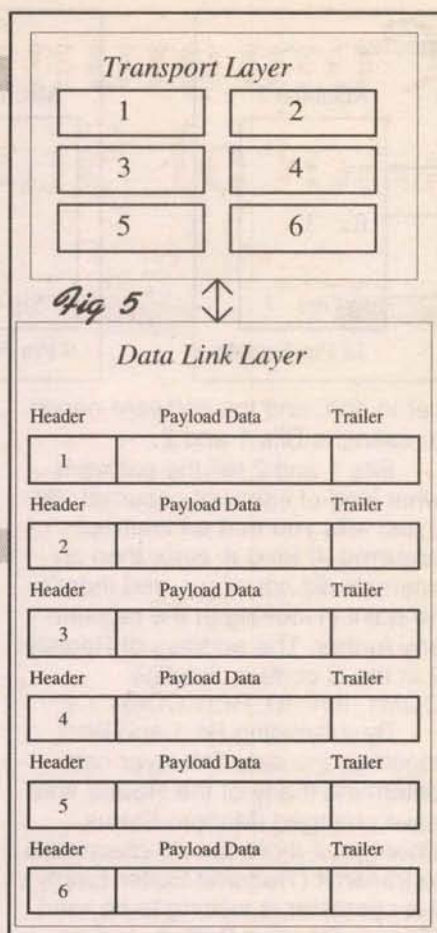
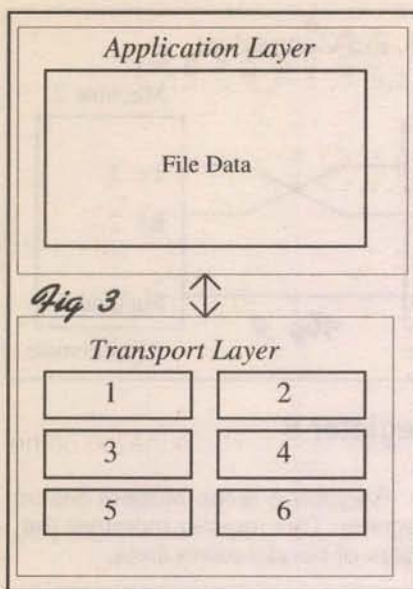
In the early days of computing, a lot of smart people spent untold hours of frustration trying to get computers to communicate reliably. Along with the frustration came potentially vast rewards. By getting

conceptual model of a layered protocol stack is shown in Figure 1.

The key to understanding layered models is understanding the difference between a protocol and interface. A protocol is an agreed method of communication between layers. An interface is defined as the services available from one layer to the next.

Machine 2. The Application Layer does not know, and does not care that the file is physically located on another machine. The Application Layer expects file data to be returned when it calls ReadFile(filename), nothing more, nothing less. It doesn't care about data packets, error checking methods, packet retries, or even the physical trans-





sage frames, extract the header information, and perform error checking. These functions, along with simple data packet transfer protocol functions, will appear in Part 2.

## The RS232 Physical Layer

acknowledgement byte. The frame's integrity is checked using checksums, parity calculations, or CRCs. These values are usually one or two bytes and are placed in the trailer. A generic frame is shown in Figure 4.

(The Data Link Layer frames developed in Part 2 of this article will be based on these three segments.)

Going back to the protocol stack, the Transport Layer data chunks are passed to the Data Link Layer. The Data Link Layer encapsulates the data within a header and trailer, as shown in Figure 5. The data is now ready to be passed to the Physical Layer and sent across the transmission media.

As you can see, the functionality of each layer becomes more specific and detailed as it approaches the Physical Layer. The Transport Layer simply breaks the file data from the Application Layer into smaller segments. It has no knowledge about headers and trailers, but it knows about the size and order of the data segments. The Data Link Layer has no knowledge of the specific Physical Layer transmission media.

The transmission media could

be a single wire, fiber optics, a parallel cable, or an RS232 port. The physical media may change, but that doesn't affect the Transport or Application Layers.

When the Data Link Layer protocol designers decide to implement a new hardware interface, they write and install new Data Link Layer software. This usually consists of setting hardware register values. None of the other layers care, or are even aware of the Data Link Layer change. Layered protocols were invented for transparency and interchangeability.

The Data Link Layer in our model is designed for RS232 communications and is divided into two sub-layers. These layers are the Input Queue sub-layer and the Message Buffer sub-layer, as illus-

trated in Figure 6.

The Input Queue sub-layer is on the bottom and interfaces with the Physical Layer. Characters arrive from the Physical Layer and are placed in the Input Queue, which is a circular buffer. The Input Queue is declared as an array of unsigned chars, and is named `InputQueue[MAX_QUEUE_SIZE]`.

`MAX_QUEUE_SIZE` is set to 1024 characters. Four pointers control characters entering and exiting the queue. The pointers are `*HeadPtr`, `*TailPtr`, `*StartOfQueue`, and `*EndOfQueue`.

The `*HeadPtr` and `*TailPtr` act as the service access points between the Input Queue level and Message Queue levels of the Data Link Layer.

The `*TailPtr` places the characters received from the UART receive register in the queue, and the `*HeadPtr` extracts characters from the queue. The `*TailPtr` resides in the interrupt service routine.

When the `*TailPtr` reaches the end of the queue, it wraps around to the start of the queue. The `*HeadPtr` removes the character from the Input Queue and puts it in the Message Buffer.

When the `*HeadPtr` reaches the end of the queue, it also is reset to the start of the queue. That's why the pointers `*StartOfQueue` and `*EndOfQueue` are needed. They hold the addresses of the start and end of the Input Queue.

Functions within the Message Buffer sub-layer detect the mes-

The most common way of getting two computers to communicate is using the available RS232 COM ports. Older PCs and a lot of equipment use a 25-pin connector, where most newer PCs use a 9-pin connector. A DB-25 (or 9-pin equivalent) male connector is mounted on the PC side. The pinouts for each connector are listed in Figure 7.

The code for this article doesn't use any software or hardware flow control, so the cable we'll use is a simple three-wire connection. Our cable consists of Tx (Transmit Data), Rx (Receive Data), and Signal Ground. The cable pinout for the 25- and 9-pin connectors are illustrated in Figures 8 and 9. These are the cables that go between machines, so they require female connectors.

If you don't have two machines to play with, you can make a simple loopback plug to test your software. A loopback plug is shown in Figure 10.

## Finding the COM ports

Like the parallel ports, the COM port base addresses are found in the PC's BIOS table, and are standard from machine to machine. If you want to quickly check the COM port addresses for yourself, you can use the trusty old DOS debug program.

At the C:> prompt, type debug to start the program, then enter the dump command d 0:0400. The

COM ports are at the beginning of the BIOS table, starting at address 0:0400, as shown in Figure 11.

The COM port addresses start right at the beginning of the table at address 0:0400. COM1 is at address 0:0400 with data F8 03, COM2 is at address 0:0402 with data F8 02, and so on. Remember that the data appears in Little Endian format, with the least significant byte first, and the most significant byte last.

To find the actual address of COM1, take the second byte, 03, and put it in front of the first, F8. The resulting address is 03F8. Figure 12 is a table of the serial port base addresses. The values in parenthesis, such as 0x3f8 for COM1, illustrate how C needs to see hexadecimal values.

For our data link layer C

```

*****
* Filename : datalink.h
* Description : #defines for datalink.c
* (c) 1997 Jeff Stefan
*****
* COM port defines
*****
#define COM1 0x3f8
#define COM2 0x2f8
#define COM3 0x3e8
#define COM4 0x2e8

*****
* Interrupt requests
*****
#define IRQ_3 0x0b
#define IRQ_4 0x0c

*****
* PIC address and mask values
* for INT3 and INT4.
*****
#define PIC 0x21
#define EOI 0x20
#define IRQ3_MASK 0xf7
#define IRQ4_MASK 0xef
#define DISABLE_IRQ3 0x00
#define DISABLE_IRQ4 0x10

*****
* Register defines
*****

```

```

#define COM1_INT_ENAB_REG COM1+1
#define COM1_INT_ID_REG COM1+2
#define COM1_LINE_CTRL_REG COM1+3
#define COM1_MODEM_CTRL_REG COM1+4
#define COM1_LINE_STAT_REG COM1+5
#define COM1_MODEM_STAT_REG COM1+6

#define COM2_INT_ENAB_REG COM2+1
#define COM2_INT_ID_REG COM2+2
#define COM2_LINE_CTRL_REG COM2+3
#define COM2_MODEM_CTRL_REG COM2+4
#define COM2_LINE_STAT_REG COM2+5
#define COM2_MODEM_STAT_REG COM2+6

#define COM3_INT_ENAB_REG COM3+1
#define COM3_INT_ID_REG COM3+2
#define COM3_LINE_CTRL_REG COM3+3
#define COM3_MODEM_CTRL_REG COM3+4
#define COM3_LINE_STAT_REG COM3+5
#define COM3_MODEM_STAT_REG COM3+6

#define COM4_INT_ENAB_REG COM4+1
#define COM4_INT_ID_REG COM4+2
#define COM4_LINE_CTRL_REG COM4+3
#define COM4_MODEM_CTRL_REG COM4+4
#define COM4_LINE_STAT_REG COM4+5
#define COM4_MODEM_STAT_REG COM4+6

*****
* Baudrate, databits, stopbits,
* and parity values
*****
#define SET_DLAB 0x80

```

```

#define BAUD_300 0x180
#define BAUD_1200 0x60
#define BAUD_2400 0x30
#define BAUD_4800 0x18
#define BAUD_9600 0x0c
#define BAUD_192K 0x06

#define FIVE_DATA_BITS 0x00
#define SIX_DATA_BITS 0x01
#define SEVEN_DATA_BITS 0x02
#define EIGHT_DATA_BITS 0x03

#define ONE_STOP_BIT 0x00
#define TWO_STOP_BITS 0x04

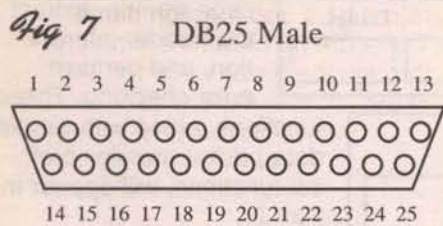
#define NO_PARITY 0x00
#define ODD_PARITY 0x08
#define EVEN_PARITY 0x18
#define MARK 0x28
#define SPACE 0x38

#define BREAK 0x00
#define NO_BREAK 0x40

*****
* Misc Defines
*****
#define SET_RxRDY 0x01
#define INT_PENDING 0x01
#define CHAR_IN_UART 0x04
#define XMIT_BUF_EMPTY 0x02
#define MAX_QUEUE_SIZE 1024

```





25-Pin	9-Pin	Signal Name
1	none	Protective Ground (see note!)
2	3	Tx Transmit Data
3	2	Rx Receive Data
4	7	RTS Request To Send
5	8	CTS Clear To Send
6	6	DSR Data Set Ready
7	5	Signal Ground
8	1	DCD Data Carrier Detect
20	4	DTR Data Terminal Ready
22	9	RI Ring Indicator

Note: NEVER use Protective Ground as a Signal Ground

code, the base port addresses declarations are:

```
#define COM1 0x3f8
#define COM2 0x2f8
#define COM3 0x3e8
#define COM4 0x2e8
```

## UARTS

The term UART stands for Universal Asynchronous Receiver Transmitter. The sending UART converts eight parallel bits into a serial data stream, and the receiving UART converts the incoming serial data stream back into eight parallel bits.

The most basic UART — the 8250 — is found in the early PCs, XT's, and clones. The 8250 can only receive and transmit one byte at a time before generating an interrupt. Most personal computers — from the advent of the IBM AT on up — contain a 16550 UART.

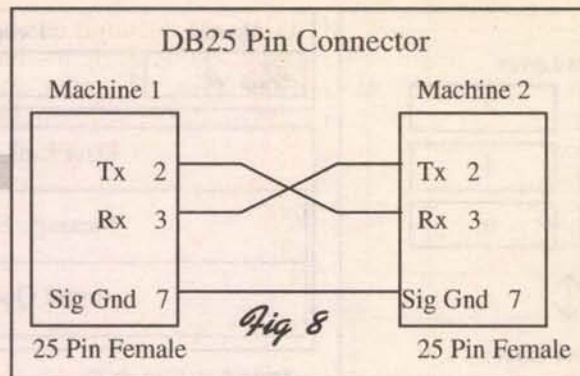
The 16550 can store up to 14 bytes before generating an interrupt, making it better suited for high throughput, multitasking applications. The 16550 can still generate an interrupt with one byte, making it compatible with the 8250. Our code uses the 8250 set-up values to remain compatible with most systems.

## 8250 UART Registers

UARTs are programmed via registers. The registers are accessed using input/output instructions, base addresses, and offsets to the base addresses. There are a lot of registers, and some of them share double and triple duty. If you want to do data link layer programming, you must understand the UART's registers.

### Register 0

Register 0 is a triple duty regis-



ter. In normal operation, Register 0 acts as the Transmit Buffer Register and Receive Buffer Register. Register 0 is at the COM base address. For COM1, its address is 3F8h. If bit 7 is set in Register 3 (Line Control Register), Register 0 also acts as the Baud Rate

Divisor Latch LSB.

### Register 1

Register 1 is the Interrupt Enable Register. Register 1 uses only four bits (bit 0 through bit 3) to enable interrupts. Bits 4 through 7 must be set to zero. Register 1 is addressed by the base port address plus one. The data link C code declaration for Register 1 is `#define COM1_INT_ENAB_REG COM1 + 1`.

This assumes that COM1 is the active serial port. If COM2 is used, the `#define` must be changed to `#define COM2_INT_ENAB_REG COM2 + 1`. The same holds for COM3 and COM4. This method allows you to keep your addresses cleanly separated if you use more than one COM port at a time.

The bit that the data link layer

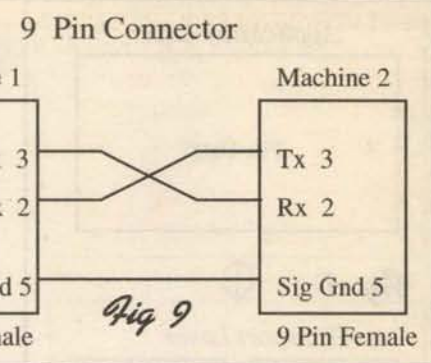
set to one, and the software needs to examine Bits 1 and 2.

Bits 1 and 2 tell the software what kind of interrupt occurred. Bit 0 just tells you that an interrupt occurred. If Bit 0 is zero, then an interrupt did not occur, and there's no point in looking at the register any further. The address of Register 2 in the C code is: `#define COM1_INT_ID_REG COM1 + 2`.

By examining Bit 1 and Bit 2 together, the data link layer can determine if any of the RS232 lines have changed (Modem Status Change), if there are no characters to transmit (Transmit Buffer Empty), if a character is waiting to be read (Char is Receive Buffer), or if an error condition or break occurred (Error or Break).

### Register 3

Register 3 is the Line Control Register. This register is used at initialization time to correctly set up the number of data bits, stop bits, type of parity checking used, and whether to recognize a break signal or not. Register 3 is addressed as `COM1_LINE_CTRL_REG COM1 + 3`.



### Register 6

Register 6 is the Modem Status Register. This register monitors the status of handshaking lines.

### Register 7

Register 7 is the Scratch Pad Register. This is a register that is not used, and should not be used, since some of the early 8250s did not have this register.

### Register 8

Register 8 is the Least Significant Byte Baud Rate Divisor Latch. This is really at the address of Register 0.

### Register 9

Register 9 is the Most Significant Byte Baud Rate Divisor Latch. This is really at the address of Register 1.

## Interrupt Service Routines

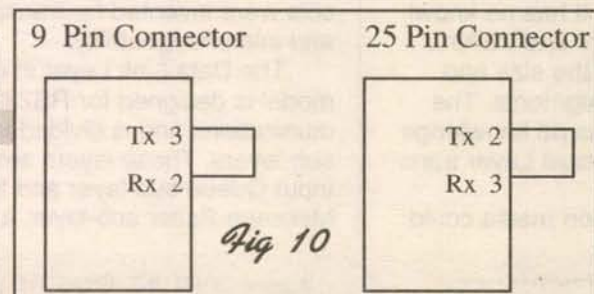
When a serial interrupt occurs, an interrupt handler must take temporary control of program execution and process the data associated with the interrupt. Just setting up the UART registers will do nothing. You need an

interrupt service routine to do the work. Our interrupt service routine, or interrupt handler as they are sometimes called, is written in C.

Most interrupt service routines are written in assembly language, including ones written for serial communications. Why is our ISR written in C? There are two reasons. The first reason is that most C compilers supply the tools to write interrupt level function calls, so why not use them? Everyone reading and using the code in this article may not have access to an assembler.

The second reason is that it's easier to write interrupt service routines in C than it is in assembly. Granted, there's more overhead in a C interrupt service routine, and in a lot of cases, there's no substitute for using assembly language. When

COM Port	Base Address	Int Num	Int Level
COM1	3F8h (0x3f8)	0x0c	4
COM2	2F8h (0x2f8)	0x0b	3
COM3	3E8h (0x3e8)	0x0c	4
COM4	2E8h (0x2e8)	0x0b	3



-d 0:0400

0000:0400 F8 03 F8 02 E8 03 E8 02- 00 00 00 00 00 00 00 00

code depends on is Bit 0, the RxRDY bit. If this bit is set to 1, then the UART will generate an interrupt whenever a character enters the Receive Buffer. To set bit 1, the C code uses `#define RxRDY_BIT 0x01`.

### Register 2

Register 2 is the Interrupt Identification Register. While Register 1 allows the interrupts to happen, Register 2 indicates which interrupts have occurred.

Register 2 can be examined in two steps. Step 1 is to examine Bit 0, the Interrupt Pending bit. If an interrupt occurred, then Bit 0 will be

### Register 4

Register 4 is the Modem Control Register. This register controls the hardware handshaking signals RTS and DTS. It also controls the General Purpose Outputs. GP02 must be set for the UART's interrupt to work on the PC.

### Register 5

Register 5 is the Line Status Register. This register is used to monitor activity on the transmission lines. Bit 0 — the RxRDY bit — can be used by an interrupt service routine to see if a character waiting to be read in the receive buffer.



I need to write an interrupt service routine I first write it in C, then see how it performs. If it works as expected, I keep it. If it doesn't perform well, then I rewrite it in assembly language.

ly language.

Turbo C/C++ supports interrupt level functions. To write an ISR, just insert the keyword interrupt in your function declaration. Our interrupt

handler is declared as void interrupt DataLinkISR(void); the function doesn't return a value, so it is of type void. The keyword interrupt is placed in between the function

return type and function name.

There are no parameters passed through the function, hence the void in the argument list.

There are a few additional

```

/*****
* Filename : datalink.c
* Description : Data Link Layer serial communications
* routines.
* Note: Compile with Large or Small Memory Model
*
* (c) 1996 Jeff Stefan
*****/

#include <stdio.h>
#include <stdlib.h>
#include <dos.h>
#include <bios.h>
#include <conio.h>

#include "datalink.h"

#define ESCAPE 0x1b
#define DEBUG

/*****
* Function prototypes
*****/
void interrupt DataLinkISR(void);
void interrupt (*OldISR)(void);

int InitCom1(void);
int DisableCom1(void);
int CheckBytes(void);
int ReadByte(void);
void WriteByte(unsigned char);

/*****
* Input queue variables
*****/
unsigned char InputQueue[MAX_QUEUE_SIZE];
unsigned char *HeadPtr, *TailPtr, *StartOfQueue, *EndOfQueue;
unsigned char PicVal=0x00;

/*****
* Input Message Buffer and index
*****/
unsigned char InputMsgBuff[MAX_QUEUE_SIZE];
int BufIdx=0;

#ifdef DEBUG
unsigned char Dbg;
unsigned int DbgCnt=0;
#endif

int main()
{
    int InChar=0x00;

    /*****
    * Init COM1 to 9600 baud, 8 data bits, 1 stop bit, and no parity
    *****/
    InitCom1();

    /*****
    * Init the input queue pointers
    *****/
    HeadPtr = TailPtr = StartOfQueue = InputQueue;
    EndOfQueue = StartOfQueue + MAX_QUEUE_SIZE;

    /*****
    * do terminal
    *****/
    while(InChar != ESCAPE)
    {
        if(kbhit())
        {
            InChar = getch();
            WriteByte(InChar);
        }
        else
        {
            if(CheckBytes())
            {
                ReadByte();
            }
        }
    }

    DisableCom1();

#ifdef DEBUG
    printf("Debug Count = %d\n",DbgCnt);
#endif

    return(0);
}

/*****
* InitComPort : initializes COM port.
*****/
int InitCom1()
{
    unsigned char PortData;

    /*****
    * Set Line Control Register DLAB bit 7
    * to enable baudrate initialization.
    *****/
    PortData = inportb(COM1_LINE_CTRL_REG);
    outportb(COM1_LINE_CTRL_REG, SET_DLAB | PortData);

#ifdef DEBUG
    Dbg = inportb(COM1_LINE_CTRL_REG);
#endif

    /*****
    * Write baudrate value to Reg0 and Reg1
    *****/
    outportb(COM1_BAUD_192K);

    /*****
    * save the old interrupt service routine at INT4
    *****/
    OldISR = getvect(IRQ_4);

    /*****
    * use setvect() to point to com ISR
    *****/
    setvect(IRQ_4,DataLinkISR);

    /*****
    * Setup Line Control Reg for eight data
    * bits, one stop bit, and no parity.
    *****/
    outportb(COM1_LINE_CTRL_REG,EIGHT_DATA_BITS |
        ONE_STOP_BIT | NO_PARITY);

#ifdef DEBUG
    Dbg = inportb(COM1_LINE_CTRL_REG);
#endif

    /*****
    * Set the Modem Control Register
    *****/
    outportb(COM1_MODEM_CTRL_REG,0x0b);

    /*****
    * set Int Enable Reg for rcv interrupt only
    *****/
    outportb(COM1_INT_ENAB_REG,SET_RxRDY);

#ifdef DEBUG
    Dbg = inportb(COM1_INT_ENAB_REG);
#endif

    /*****
    * set up PIC for INT4
    *****/
    PicVal = inportb(PIC);
    outportb(PIC,PicVal & IRQ4_MASK);

#ifdef DEBUG
    Dbg = inportb(PIC);
#endif

    /*****
    * read char from port to flush input
    *****/

#ifdef DEBUG
    Dbg = inportb(0x3f8);
#endif

#ifdef DEBUG
    Dbg = inportb(0x3f8);
    Dbg = inportb(0x3f9); // int enab
    Dbg = inportb(0x3fb); // line ctrl
    Dbg = inportb(0x3fc); // modem ctr
    Dbg = inportb(0x3fd); // line status
    Dbg = inportb(0x3fe); // modem status
    Dbg = inportb(0x21); // PIC
#endif

    return(0);
}

/*****
* DisableCom1 : disables COM1 port.
*****/
int DisableCom1()
{
    /*****
    * restore old interrupt service routine
    *****/
    setvect(IRQ_4,OldISR);

    /*****
    * restore old PIC value
    *****/
    PicVal = inportb(PIC);
    outportb(PIC,PicVal | DISABLE_IRQ4);

#ifdef DEBUG
    Dbg = inportb(PIC);
#endif
}

return(0);
}

/*****
* DataLinkISR : serial port interrupt service routine.
*****/
void interrupt DataLinkISR(void)
{
    unsigned char InChar;

    enable();

    InChar = inportb(COM1);
    if(TailPtr == EndOfQueue)
    {
        TailPtr = StartOfQueue;
        *TailPtr++ = InChar;
    }
    else
    {
        *TailPtr++ = InChar;
    }

#ifdef DEBUG
    DbgCnt+=1;
#endif

    /*****
    * re-enable PIC interrupts
    *****/
    outportb(EOI,EOI);
}

/*****
* CheckBytes : checks if queue contains unread chars. Returns
* zero in no bytes in queue, else returns number
* of chars in queue.
*****/
int CheckBytes(void)
{
    /*****
    * check if head pointer == tail pointer
    * if ==, no chars are in buffer: return(0);
    * num chars = abs diff from head to tail
    * return num chars.
    *****/
    if(HeadPtr - TailPtr)
    {
        return(abs(HeadPtr - TailPtr));
    }
    else
    {
        return(0);
    }
}

/*****
* ReadByte : reads a byte from the queue
*****/
int ReadByte(void)
{
    /*****
    * check if head pointer == tail pointer
    * if ==, no chars are in buffer: return(0);
    *****/
    if(HeadPtr >= TailPtr)
    {
        HeadPtr = StartOfQueue;
        return(0);
    }
    else
    {
        printf("%c",*HeadPtr);
        HeadPtr++;
    }
    return(0);
}

/*****
* WriteByte : writes a byte out the serial port
*****/
void WriteByte(unsigned char CharToSend)
{
    /*****
    * Wait for the transmit flag to clear
    *****/
    while((inportb(COM1_LINE_STAT_REG) & 0x20) == 0)
    {
    }

    /*****
    * Output the byte
    *****/
    outportb (COM1,CharToSend);
}

```



### Register 0

#### Transmit Buffer Register / Receive Buffer Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

### Register 2

#### Interrupt Identification Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	Interrupt Type Table	Int Pend	

**Bit 0** If = 0, interrupt occurred. If = 1, interrupt occurred

**Bit 1-2** Interrupt Type Table if = 0.

Bit 2	Bit 1	Type
0	0	Modem Status Change
0	1	Transmit Buffer Empty
1	0	Char in Receive Buffer
1	1	Error or Break

**Bit 3 - 7** Always 0

### Register 3

#### Line Control Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

**Bit 0 - 1** Number of Data Bits

Bit 0	Bit 1	
0	0	5 data bits
0	1	6 data bits
1	0	7 data bits
1	1	8 data bits

**Bit 3 - 5** Parity

Bit 5	Bit 4	Bit 3	
0	0	0	NO Parity
0	0	1	ODD Parity
0	1	1	EVEN Parity
1	0	1	MARK
1	1	1	SPACE

**Bit 2** If 0, 1 stop bit, if 1, 2 stop bits

**Bit 6** 1 = BREAK, 0 = No BREAK

**Bit 7** Divisor Latch Access Bit (DLAB)

If = 0, Normal Operation

If = 1, Baud Rate Divisor Latch

### Register 1

#### Interrupt Enable Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	Modem Status	Error / Break	TBE	RxRDY

**Bit 0** RxRDY When set to 1, generates interrupt when char is in Receive Buffer Register

**Bit 1** TBE When set to 1, generates interrupt when char is ready to xmit in Transmit Buffer Register

**Bit 2** Error/Break When set to 1, generates interrupt whenever a parity error, framing error, break, or overrun

**Bit 3** Modem Status When set to 1, generates interrupt whenever any RS232 input line changes

**Bit 4 - 7** Unused (always set these bits to 0)

1. Write the baudrate values to the UART.
2. Save the old ISR at the interrupt vector and install the new COM ISR.
3. Set up the UART's Line Control Register to the desired control values (data bits, parity, etc.).
4. Set the UART's Interrupt Enable Register to enable the receive interrupt.
5. Set the bit for the ISR in the PIC register.

### Low-Level Functions

The Input Queue sub-layer functions are `InitCom1()`, `DisableCom1()`, `CheckBytes()`, `ReadByte()`, `WriteByte()`, and the interrupt service routine `DataLinkISR()`. The key data structure is the array `InputQueue[MAX_QUEUE_SIZE]`, and its associated pointers. The function `InitCom1()` initializes COM1 to 19.2K baud, 8 data bits, 1 stop bit, and no parity.

A function to initialize COM2 can be easily written by substituting the COM2 definitions in place of the COM1 definitions.

`DisableCom1()` restores the original interrupt service routine and restores the original PIC value. The `CheckByte()` function checks to see if any characters are in the `InputQueue`. The `ReadByte()` function extracts a character from the input queue using the `*HeadPtr`. The `WriteByte()` function sends a character out the serial port.

The `InputQueue` array pointers are initialized by setting `HeadPtr = TailPtr = InputQueue`. This sets the pointer addresses to the start of the `InputQueue` array. The `EndOfQueue` pointer is initialized to `StartOfQueue + MAX_QUEUE_SIZE`, effectively setting `EndOfQueue` to the ending address of `InputQueue`.

The function that does most of the work is the com port initialization function `InitCom1()`. This function sets up the UART registers, saves the original ISR, installs the new ISR, and sets up the PIC to recognize the newly installed ISR. Read the comments in the code list-

ing for `InitCom1()` for step by step details.

You will notice that a debug variable, named `Dbg`, appears frequently in the function and throughout the code. When I develop interrupt service routines and code that involves accessing and controlling the PC's hardware, I always use one or two debug variables to examine the contents of the hardware's registers, especially just after writing to them. That way it's easy to verify that the registers are set correctly when stepping through the code in a debugger. This is especially handy when trying to set the PIC to recognize a newly installed ISR.

The other debug variable used is `DbgCnt`, which resides in the `DataLinkISR()` interrupt service routine. This is the easiest way to see if your interrupt service routine is being called. Every time the ISR runs, `DbgCnt` increments by one. When the program terminates, the value of `DbgCnt` is printed, telling you how many times the ISR was called.

If `DbgCnt` is zero, then your ISR never ran, so it may not be installed at the right address or the PIC may be set up incorrectly. If `DbgCnt` is one, then your ISR ran one time only, so you probably didn't re-enable the PIC interrupt correctly. It's amazing what a simple counter can tell you!

The heart of the Input Queue sub-layer is the `DataLinkISR()` function. This is the interrupt service routine that reads characters from the physical layer, which is the UARTS receive register. Here's the ISR code:

```
void interrupt DataLinkISR(void)
{
    unsigned char InChar;

    enable();
    InChar = inportb(COM1);
    if(TailPtr == EndOfQueue)
    {
        TailPtr = StartOfQueue;
        *TailPtr = InChar;
    }
    else
    {
```

things you need to do to ensure that your ISR works correctly. You need to turn off the Stack Warning option, and you need to make sure that the Register Variables option is set to none. To set these values, select Options from the top menu bar. You can set these options in the Linker and Optimizations menu selections.

One little pitfall using an interrupt service routine with an Intel processor is that interrupts are automatically disabled when inside an ISR. Sometimes this is okay, if the code is critical and cannot be pre-empted by another ISR. Usually, interrupts should be immediately re-enabled inside an ISR. This is done by calling the `enable()` macro. This macro is defined as `asm sti`, which is the assembly language instruction to enable interrupts. Our ISR immediately upon entry calls `enable()`.

One last chip must be set up before an ISR can work. This chip is the 8259 Programmable Interrupt Controller, or PIC. There are two PICs in a PC and each of the inter-

rupt requests — IRQ0 through IRQ15 — are wired to the PICs.

In order to get an ISR to run, a bit corresponding to the ISR must be set in the PIC. This is done by writing a mask value to address 0x20. One common mistake when writing ISRs, especially in embedded systems programming, is to forget to set the PIC.

Another common mistake is to forget to reset the PIC after an interrupt occurs. This is done by writing an End of Interrupt, or EOI to address 0x21. If this isn't done, then your interrupt service routine will run one time, and one time only. Resetting the PIC is done within the ISR. In our ISR, this is done by the `outportb(PIC,PIC)` instruction.

If this seems like a lot of complicated grunt work, you're right. But it's worth taking the time to become familiar with the PC's hardware. It aids in your mastery of the machine. It allows you to control the computer, and not vice-versa. Here's the checklist for installing an interrupt service routine:



### Register 4 Modem Control Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	Local Loop Back	GP02	GP01	RTS	DTR

- Bit 0** DTR (Data Terminal Ready) If set to 1, DTR line goes high, if set to 0, DTR line goes low
- Bit 1** RTS (Request to Send) If set to 1, RTS line goes high, if set to 0, RTS line goes low
- Bit 2** GP01 (General Purpose Output 1) User definable output
- Bit 3** GP02 (General Purpose Output 2) User definable output
- Bit 4** LL (Local Loopback) If set to 1, enables loopback function
- Bit 5 - 7** Always 0

### Register 5 Line Status Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0							

- Bit 0** RxDY If = 1, char is ready to read in buffer (Register 0). If = 0, no char in buffer
- Bit 1** If = 1, overrun error occurred
- Bit 2** If = 1, parity error occurred
- Bit 3** If = 1, framing error occurred
- Bit 4** If = 1, BREAK detected
- Bit 5** If = 1, transmit buffer is empty and ready for another character
- Bit 6** If = 1, transmit buffer is flushed
- Bit 7** Always 0

### Register 6 Modem Status Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CD state	RI state	DSR state	CTS state	CD	RI	DSR	CTS

- Bit 0** If = 1, CTS line changed since last read
- Bit 1** If = 1, DSR line changed since last read
- Bit 2** If = 1, RI line changed since last read
- Bit 3** If = 1, CD line changed since last read
- Bit 4** Indicates state of CTS line
- Bit 5** Indicates state of DSR line
- Bit 6** Indicates state of RI line
- Bit 7** Indicates state of CD line

```
*TailPtr++ = InChar;
}
outportb(EOI,EOI);
}
```

As you can see, the ISR is short and relatively simple. Upon entry, interrupts are re-enabled by calling enable(), then a character is read from COM1. Before the character is placed in the queue, the TailPtr is tested to see if it's at the end of the queue. If it is, then the TailPtr is reset to StartOfQueue

and only then is the character placed in the queue. The TailPtr then advances to the next queue position. Finally, the 8259 PIC is re-enabled by the outportb(EOI,EOI) function.

Characters are extracted by the ReadByte() function, which is very simple. The code for ReadByte() is:

```
int ReadByte(void)
{
    if (HeadPtr >= TailPtr)
```

### Register 7 Scratchpad Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

General pupose scratchpad register (not on early 8250s)

### Register 8 (Resister 0) LSB Baud Rate Divisor Latch

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

This is the Least Significant Byte value used to set the 8250 baudrate. Register 8 is accessed by setting bit 7 of the Line Control Register (Register 3) to 1.

### Register 9 (Resister 1) MSB Baud Rate Divisor Latch

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

This is the Most Significant Byte value used to set the 8250 baudrate. Register 9 is accessed by setting bit 7 of the Line Control Register (Register 3) to 1.

#### Baud Rate Divisor Latch Values

Baud Rate	Latch Value
300	384
1200	96
2400	48
4800	24
9600	12
19.2K	6

```
{
    HeadPtr = StartOfQueue;
    return(0);
}
else
{
    printf("%c", *HeadPtr);
    HeadPtr++;
}
return(0);
}
```

On entry, the HeadPtr is tested against the TailPtr and is set to the StartOfQueue if it's out of bounds. The extracted character is printed and the HeadPtr is advanced to the next character in the InputQueue array.

The CheckByte() function calculates the difference between the \*HeadPtr and \*TailPtr to determine the number of characters in the buffer. The WriteByte() function reads the Line Status Register (Register 5) and checks if the transmit buffer is empty by performing a logical and with Bit 5. If Bit 5 is set to one, then the transmit buffer is ready to send another character.

The outportb(COM1, CharToSend) function sends the new character out the serial port.

That's it for the lowest level of the Data Link Layer. With these functions in place, frames can be built and detected, and protocols can be developed to support high level functions such as file transfer, remote procedure calls, and client/server applications.

These simple functions are the mortar that hold virtual machines together. The example program, datalink.c, and its associated header file datalink.h, allows characters to be received and transmitted between machines. You are encouraged to experiment with the code. The code is left intentionally sparse so you can easily modify it.

In Part 2, we will build frames from the InputQueue based on the read/write functions, evaluate various error checking methods such as checksums and CRCs, and build a simple protocol that you can use to transfer data packets from machine to machine. **NV**



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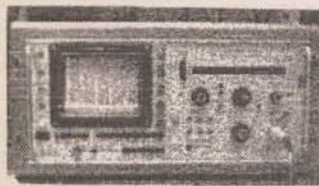
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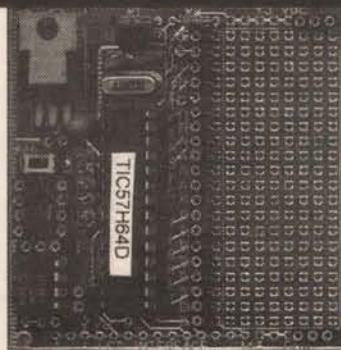
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# More on Data Acquisition and Sensor Resolution

# Open Channel

by Joseph J. Carr  
K4IPV

In past columns, I've talked about sensor resolution improvement (SRI). The response to those columns has been fantastic. The E-Mail I've received indicates that it struck a nerve. I've also received some update ideas on the design from readers. Already reported last month is the use of a small constant in the denominator to keep the equation from going off the top of sanity when the sensor outputs are the same. Recall that method used two sensors aligned to pick up the same target. If V1 and V2 are the output voltages of the two sensors, then the SRI circuit produces an output calculated from:

$$V_o = \frac{V1 + V2}{k + (V1 - V2)} \quad 1$$

The value of k is set to produce a full-scale output when V1-V2 = 0.

Speake & Co. Ltd., of Wales, UK, represented in the USA by Fat Quarters Software [24774 Shoshonee Drive, Murrieta, CA 92562; 909-698-7950 (voice), 909-698-7913 (FAX)], is designing a special Applications Specific Integrated Circuit, type no. JC101R, to implement the two-sensor method using FGM-3 flux-gate magnetic sensors. I suspect that the JC101R chip will also work with other sensors that produce a frequency output similar to the FGM-3.

Another reader pointed out that the two-sensor method can be implemented in either analog or digital circuitry. A single-sensor method can be implemented in digital circuitry, although analog implementation might work with some kind of "bucket brigade" arrangement of capacitors.

## Single-Sensor SRI Method

The two-sensor method of SRI produces startling results, but at the cost of two sensors. Another approach uses a single sensor and a look-ahead calculation to synthesize V2.

Assume that the values of V1 from the sensor are a series V<sub>i</sub> in which each value represents the signal amplitude at sequential locations along the X-axis:

V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 ... V<sub>ith</sub>

Each value of V<sub>i</sub> represents a value of V1 in Equation 1 above. The corresponding value of V2 in Equation 1 is found by taking a subsequent value of V1 that is displaced a distance N (an integer) from V<sub>i</sub>. Thus, in terms of Equation 1:

$$\begin{aligned} V1 &= V_i \\ V2 &= V_{i+N} \end{aligned}$$

Equation 1 can be rewritten to the form:

$$V_o = \frac{V_i + V_{i+N}}{k + (V_i - V_{i+N})} \quad 2$$

When the V1 data from the experiment are plotted, the resultant curves are as shown plotted in Figure 1, and demonstrate very nearly the same degree of SRI as the two-sensor method.

In addition to some bench testing, I also did some modeling in an Excel spreadsheet, and in a

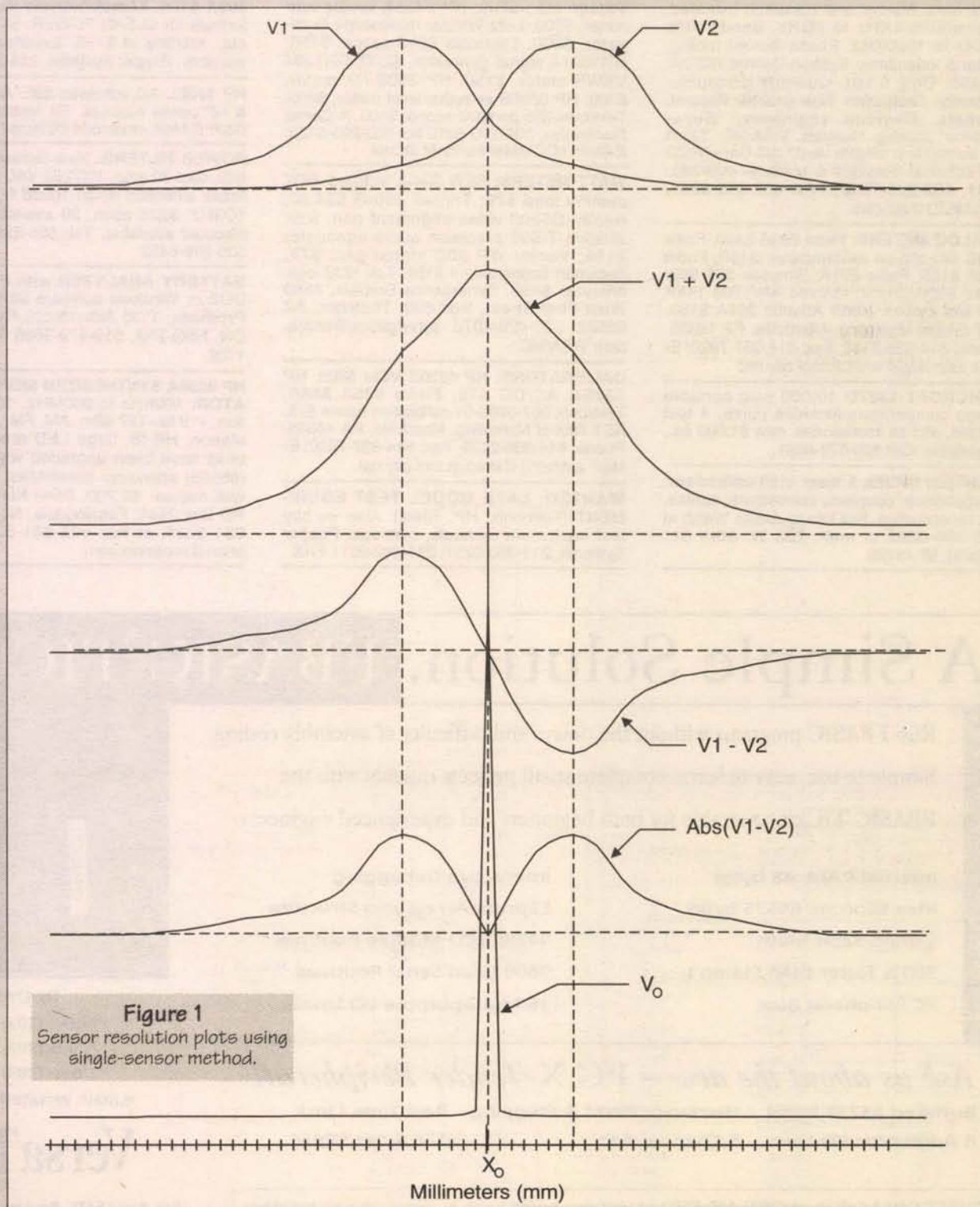
simple Visual BASIC 4.0 program that I wrote. The VB4 program allowed different values of N to be used. It was found that a limited amount of "tuning" of resolution can be done by selecting values of N. However, with the 1 mm spacing used in the original optical experiment, values N > 6 showed essentially the same curves.

In both the single-sensor and two-sensor methods, there exists the possibility of creating a selectable beamwidth sensor system. Signal V<sub>o</sub> could be the narrow beamwidth signal, V1 + V2 can be the wide beamwidth signal, and V1 (or V2) can be the medium beamwidth signal. It is

possible to use this method in a detector that will use the wide area curve to search in a rough manner, followed by progressively narrower searches using V1 and V<sub>o</sub>.

## A/D Converter Applications

The series on A/D converters prompted a number of questions about A/D converter applications. Let's take a look at some generic



**Figure 1**  
Sensor resolution plots using single-sensor method.



# Open Channel

versions of the concept in hopes that you will be able to create your own from the basic ideas presented.

**Battery Discharge Indicator.** Figure 2 shows the circuit for a computer-based battery discharge indicator. This circuit will monitor the voltage of a battery, and input the value to the computer. Such circuits are used to monitor remote batteries or emergency batteries that don't get a lot of attention between needs. You can write a simple BASIC or Visual-BASIC program to keep track of the voltage, and sound the alarm or take corrective action when it is low.

The battery V1 has a normal load circuit. It also has a voltage monitoring circuit consisting of R1 and R2, plus the A/D converter. The total resistance of R1 + R2 should be very much higher than the load resistance. The idea is to keep the current drawn by instrumentation circuit R1/R2 from discharging the battery as fast as the load!

Resistors R1 and R2 form a voltage divider circuit. The voltage applied to the V<sub>IN</sub> input of the A/D converter is:

$$V_{IN} = \frac{V1 \times R2}{R1 + R2} \quad 3$$

The A/D input is a fraction of the applied V1 battery voltage. For monitoring 12-volt systems (which are really 13.6 volts!), using a 0 to 5 volt A/D converter, solve Equation 3 for the ratio of R1 and R2 that yields 5/14, or 0.357 (sounds like a pistol caliber, doesn't it?). For example, if R1 is 10K, then R2 should be 5.55K ... which is close enough to the 5.6K standard value that it might not matter. Alternatively, you can make R2 a 10K multi-turn potentiometer and adjust the output voltage sent to the A/D converter voltage input to +5.00 volts when the battery is fully charged.

**Generic Resistive Sensor Circuit.** Many sensors use some phenomenon that translates into an electrical resistance or the change in electrical resistance in response to the measured

stimulus. For example, a thermistor produces a resistance that is proportional to temperature, while a photoconductive cell (e.g., CdS) produces a resistance inversely proportional to light level. A potentiometer can be used as a position sensor (if linear actuated) or angle sensor (if rotary actuated). The Wheatstone Bridge A/D interface shown in Figure 3 will work to convert the resistance to a voltage that the A/D converter can read.

Note that there are two lines going into the A/D converter V<sub>IN</sub> terminal. These are differential lines, rather than a voltage line and ground. The Wheatstone Bridge is inherently differential output in nature, so requires a differential input on the circuit following. Many A/D converters can use two analog input channels to provide a differential input. For example, one A/D that I use has 16 channels single-ended, or 8 channels differential.

The value of V<sub>IN</sub> produced by the Wheatstone Bridge is a function of the ratios of R1/R2 and R3/R<sub>S1</sub>. As long as R1/R2 = R3/R<sub>S1</sub>, the output voltage from the bridge is zero. This neat little feature makes it possible to set a zero value. The value of V<sub>IN</sub> to the A/D converter is:

$$V_{IN} = V \times \left[ \frac{R2}{R1 + R2} - \frac{R_{S1}}{R3 + R_{S1}} \right] \quad 4$$

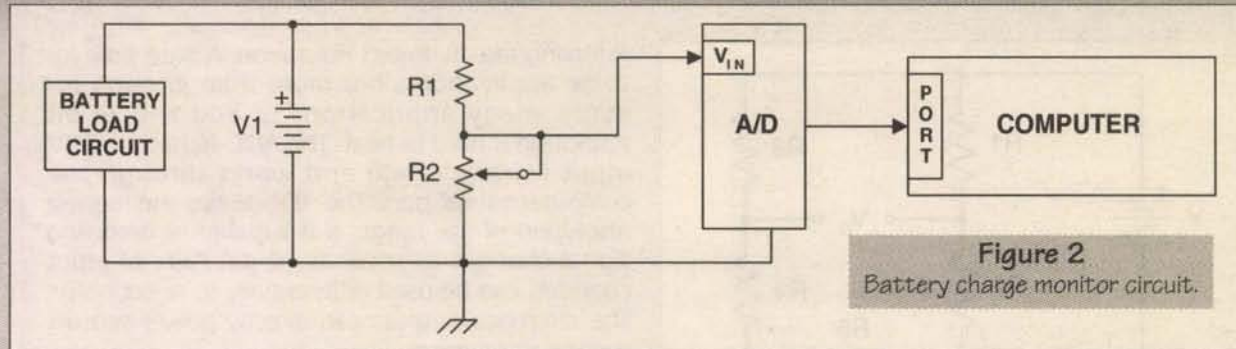


Figure 2  
Battery charge monitor circuit.

The normal procedure is to make R1, R2, and R3 somewhere near the same order of magnitude as R<sub>S1</sub>, but there is wide latitude for variation.

If your A/D converter does not allow differential operation, then use a differential amplifier at the output of the Wheatstone Bridge to convert the output to single-ended. This circuit also has the advantage of providing amplification ... which helps when the Wheatstone output is small. If R4 = R5 = R6 = R7, then the gain is unity (1). Otherwise, the gain is R7/R4, provided that R4 = R5 and R6 = R7. In some cases, R6 is made from either a multi-turn trimpot, or a multi-turn trimpot plus a fixed resistance. This is done to make it possible to adjust the common mode rejection ratio (CMRR) of the circuit to produce a zero output voltage when the differential input voltage is zero.

Wheatstone Bridge sensor circuits often produce an unwanted offset voltage, i.e., an output voltage when R1/R3 is supposed to be equal to R3/R<sub>S1</sub>. In order to overcome such errors, some designers place a BALANCE control in the circuit. An example is shown as R5 in Figure 5. The BALANCE control can also be placed in the positive side of the line, i.e., between R1 and R3. The resistance of R5 is adjusted for V<sub>O</sub> = 0 when the stimulus is also zero (or at some value we like to call zero, e.g., 0°F).

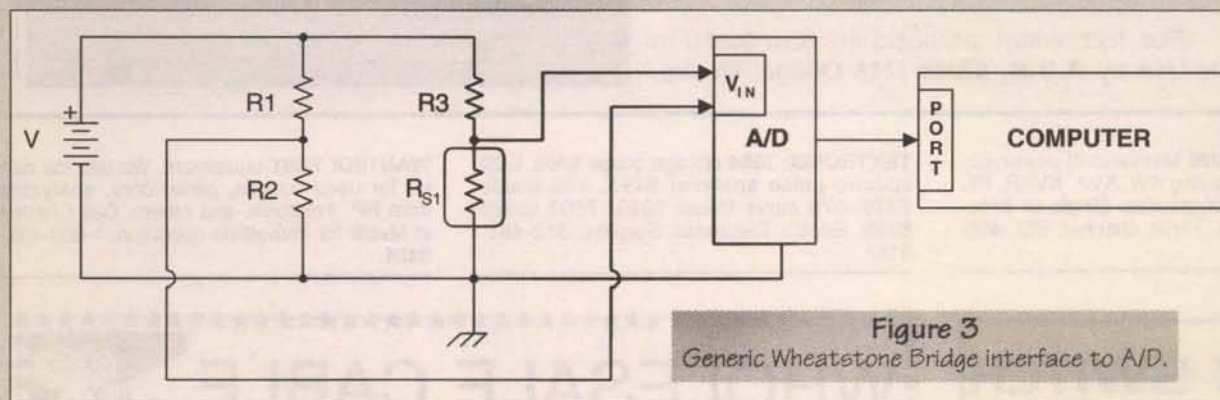


Figure 3  
Generic Wheatstone Bridge interface to A/D.

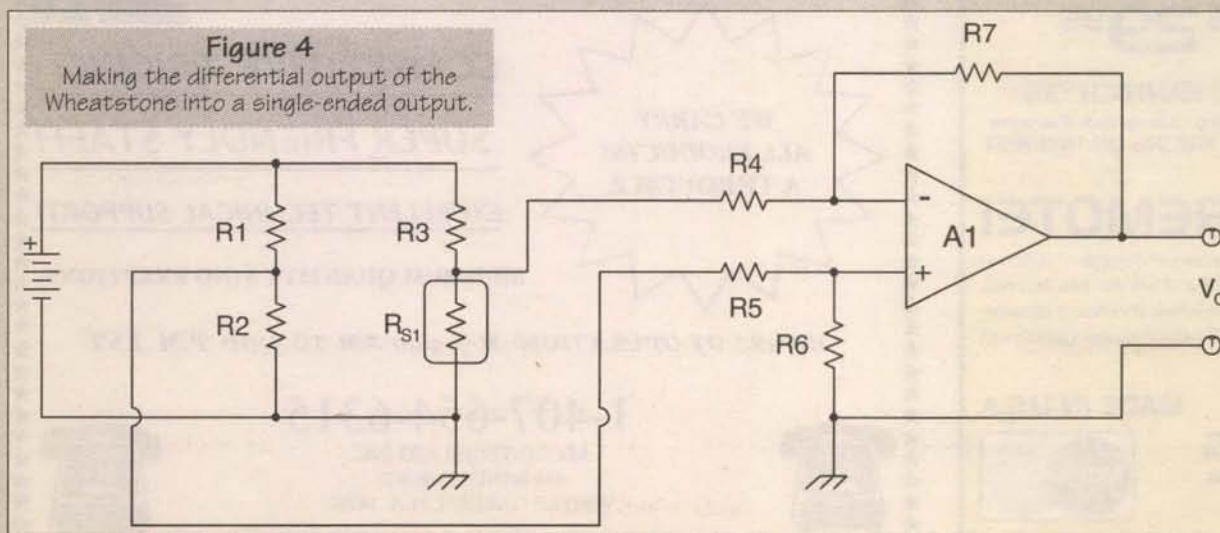


Figure 4  
Making the differential output of the Wheatstone into a single-ended output.

## My A/D (Plus Others)

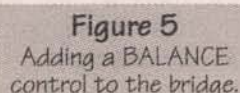
The A/D converter that I use works through the serial port of a personal computer. The software is in a DOS-compatible, so it will work with either DOS only or Windows 3.x machines. The device is made by **Pico Technology Ltd.** (Broadway House, 149-151 St. Neots Road, Hardwick, Cambridge, CB3 7QJ, England). They can be E-Mailed at [post@picotech.co.uk](mailto:post@picotech.co.uk), or via the worldwide web at <http://www.picotech.co.uk/> — Pico Tech accepts Visa, MasterCard, and American Express, so you can order from the USA. I have had no problems ordering from UK forms via credit card, so I don't anticipate any in the future. Also, I have never been charged import duty ... all came "passed free" by the US Customs Service. I cannot guarantee that yours will come that way, but it's likely.

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**ADC-16.** This is the product I used on some of my set-ups. It has been used for a number of sensor applications, as well as logging VLF radio station signal strength for solar flare and Sudden Ionospheric Disturbance (SID) detection. It is the highest resolution product. The sample rate is 200 Hz sampling at 8-bits resolution, and 2 Hz

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# Build a three-axis stepper motor controller

by  
Daniel Eggert

**Control up to three stepper motors simultaneously and independently using your serial port**

The SSC (Serial Stepper Controller) interface can control up to three four-phase unipolar stepper motors simultaneously and independently with commands sent from your personal computer's serial port.

Stepper motor motion is performed by the SSC interface in the foreground while it receives commands from your PC in the background. All three stepper motors are independent of each other. While one stepper motor is in motion, you can be setting up step counts and direction for another stepper motor. Your PC can be busy computing the position coordinates for the next move while the SSC interface is positioning from previous commands.

The SSC interface was designed to control four-phase unipolar stepper motors because they can be found in many surplus catalogs for reasonable prices, and they can be salvaged from older, obsolete equipment.

I have an abundance of these stepper motors that were removed from old printers and disk drives. The paper feed motor and print head positioning motors of printers are usually stepper motors. Later on, I will describe a simple procedure to help you determine the proper phase connections of salvaged stepper motors.

The SSC interface circuit board design is simple and straightforward. It includes an RS-232 interface, several buffered general-purpose digital inputs and outputs, and 12 power drive transistor circuits for the three stepper motors.

All you need to control the motion of three stepper motors is the SSC interface circuit board, a serial interface cable to connect it to your PC, and power sources for the interface and stepper motors.

Example programs are provided in support of this project to help you get started with your CNC (Computer Numeric Control) and robotics projects.

The QuickBasic stepper motor exerciser program provided with this article

illustrates just how easy it is to command and control the SSC interface. The programs available from the source given in the note at the end of the Parts List include more complex GWBASIC, QuickBASIC, and Visual BASIC stepper motor exerciser programs, and a QuickBasic application program for drilling holes with a three-axis positioning system. A pre-programmed 8751 microcontroller and a binary file for programming your own 8751 are also available in the Parts List.

Figure 1 illustrates how the various components of the SSC system are interconnected to the interface circuit board. Only one of the three stepper motors is shown connected in this illustration.

Table 1 shows the stepper motor drive output step sequence logic states for the three possible modes of operation: One phase excitation; two phase excitation; and half step are the three modes of operation. The one and two phase excitation modes are sometimes referred to as monophasic and biphasic modes. All three of the stepper motors can use different modes.

The S in the step direction columns on the left side of Table 1 indicates the starting point where the stepper motor is at rest after initialization takes place.

The rows to the right of each of the steps in the CW and CCW direction columns indicate the output logic states of the P1, P2, P3, and P4 terminals on the interface circuit board for all three modes. A black square indicates that the stepper motor coil will be energized.

The SSC system has 14 different commands. The first three commands initialize the interface for full or half step mode, one or two phase excitation mode, and mechanical limit sense. Nine of the commands control stepper motor motion. One command reads the logic states of 11 digital inputs. One command controls the logic states of seven general-

purpose digital outputs.

There are five general-purpose digital inputs available for use. An additional six digital inputs are selected at system initialization for either stepper motor mechanical limit sense inputs or general-purpose digital inputs.

If they are initialized as stepper motor mechanical limit sense inputs, then the stepper motor will stop immediately whenever a limit is reached. If limit switch sense inputs are not needed on some or all stepper motors, then these inputs can be used for various other things.

## About the Circuit

The schematic diagram of the SSC interface is shown in Figure 2. The heart of the circuit is the 8751 microcontroller IC1. All four output ports of the microcontroller are buffered with IC2 through IC5. These 74HC541 octal buffer and line driver ICs are used to protect the microcontroller's I/O lines and provide adequate output levels. The reset signal for IC1 is provided by R1, C1, and D1. JP1 is a two-pin header on the circuit board that can be momentarily shorted for resetting the interface, if necessary. You can connect a remote reset switch to the pins of JP1. The RS-232 serial port circuitry at IC6 utilizes a MAX232 which has built-in charge pump voltage converters and RS-232 receivers and transmitters.

The embedded controller IC1 has a built-in serial interface with a programmable baud rate generator. The RS-232 transmit signal from the host PC enters the SSC interface at terminal strip TS3 pin RX. The signal enters IC6 at pin 13 and is converted from an RS-232 level to a TTL level signal at pin 12. The signal is then buffered by one of the eight circuits of IC3 on its way to pin 10 of IC1, the microcontroller's serial receive data input. The serial data transmitted by the SSC interface to the host PC is sent out of IC1 pin 11, the microcontroller's serial transmit data output. This TTL level signal is then buffered by one of the eight circuits of IC3 on its way to pin 11 of IC6. IC6 converts this TTL signal to an RS-232 level at pin 14 and then on to terminal strip TS3 pin TX.

A frequency of 11.0592 MHz was chosen for crystal Y1 so that IC1 can generate the SSC system's fixed communication rate of 9600 baud.

All of the SSC interface digital inputs are pulled up to +5 volts by the 10K ohm resistors in the resistor network RN1, and resistors R2, R3, and R4.

The SSC interface digital inputs are connected at terminal strip TS1 pins I1 through I7 and terminal strip TS2 pins I8 through I11. Their common ground connection is located at terminal strip TS1 and TS2 pin G. The optional mechanical limit sense inputs are digital inputs I1 through I6 and are labeled on the schematic diagram of Figure 2 and listed on the wiring guide of Figure 5.

A normally closed switch contact connected to a digital input and ground is all that you need for a mechanical limit sense switch input. The SSC interface requires an unregulated DC input between 9 and 12 volts at about 200 milliamps connected at terminal strip TS7. This power source can be from a common nine-volt DC power adapter.

The voltage regulator VR1 provides

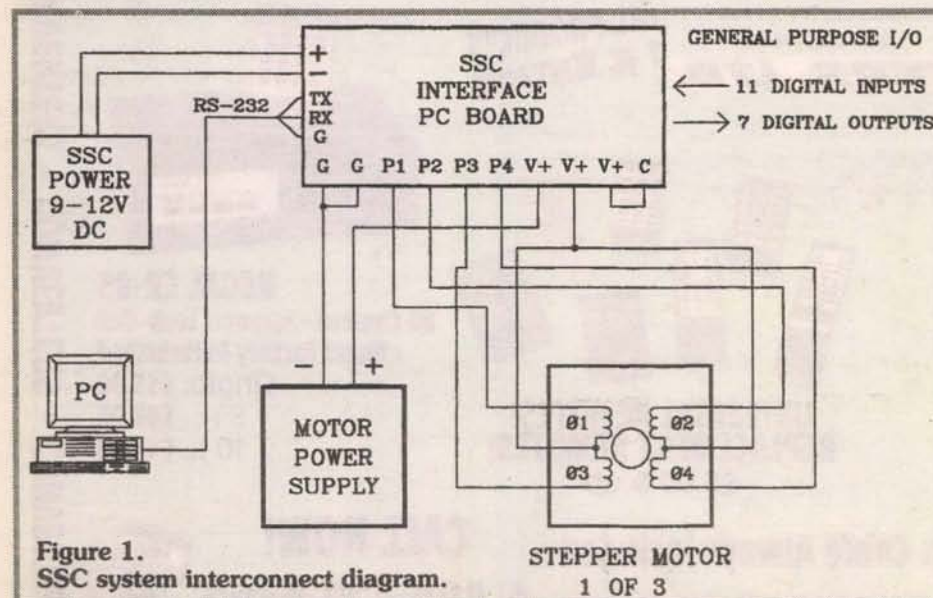


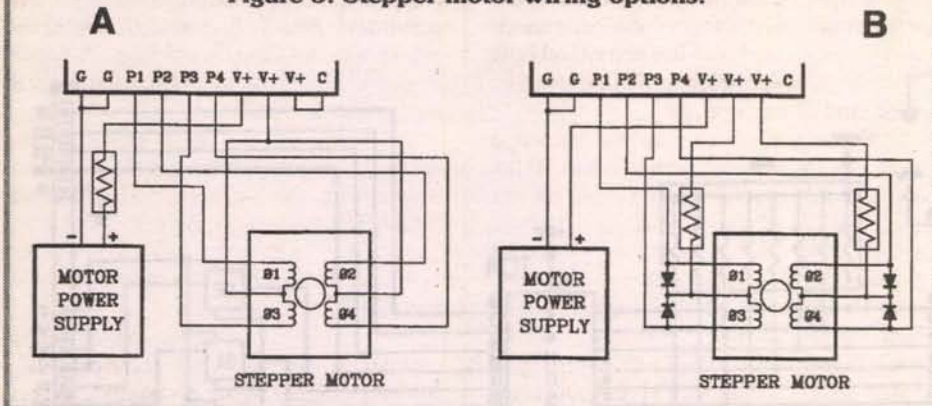
Figure 1.  
SSC system interconnect diagram.







**Figure 3. Stepper motor wiring options.**



press are rated 5.5 volts at 1.3 amps per phase. The stepper motor that raises and lowers the drill press is rated 5.0 volts at 450 milliamps per phase. A power resistor was placed between the positive lead of the 12-volt power supply and a V+ terminal of each of the stepper motor drive output terminals. The resistance values and power rating of these resistors were determined using Ohm's law.

When calculating the resistance value, you must take into account that the TIP120 transistors have an emitter-to-collector voltage drop of approximately .7 volts when conducting.

Therefore, the resistors for the two table top positioning motors must drop 5.8 volts and dissipate 7.54 watts of power. I used 4.5-ohm, 25-watt power resistors for these two stepper motors. A 14-ohm, 10-watt resistor was used for the drill press stepper motor.

The IRF540 power MOSFET transistors drain-to-source voltage drop when conducting is dependent upon the resistance of its drain-to-source (RDS) and the amount of current it is sinking. I found this to be about 200 millivolts when sinking 1.3 amps of current.

By adding voltage dropping resistors as illustrated in Figure 3A, you will be limited to one or two phase excitation modes only. If you use two phase excitation mode, then you must use a power resistor of half the resistance value and twice the power rating as calculated previously.

There is always two phases energized with two phase excitation mode. The voltage drop across the power resistor is the same, but twice the current will flow through it.

If you want to use half step mode, then you will have to place voltage dropping resistors in series with both of the stepper motors center tapped coil wires as illustrated in Figure 3B.

Also, as illustrated, you must disable the on-board clamp diodes by omitting the jumper wire between terminals V+ and C on the stepper motor drive output terminal strips and provide externally connected clamp diodes directly across each of the four stepper motor phase windings.

I recommend using a higher voltage power supply and voltage dropping resistors as illustrated in Figures 3A and 3B. If the voltage source for the motor coils is fixed as in Figure 1, then the current through the coils will decrease as the step rate increases due to an increase in the coils inductive reactance. When the current decreases, the stepper motor torque also decreases.

With the fixed power resistor in series with the coil and a higher voltage power supply, the voltage will rise across the coil when the inductive reactance increases. This improves the torque of the stepper motor at higher step rates. A power supply voltage of about twice the stepper motor's voltage rating is recommended.

The ultimate motor power supply would be one that provides a constant current to each of the motor coils when it is stepping, and then switch to a considerably lower current to hold its position when it is not stepping.

### Construction

Though you can build this circuit on

perforated board that has holes on 0.1 inch centers using suitable wire wrap or soldering hardware, a printed circuit board is recommended.

You can use the actual-size etching-and-drilling guide in Figure 4 to fabricate your own circuit board if you like, or purchase a ready-to-wire board from the source given in the Note at the end of the Parts List. This board has the parts layout silk-screened on the top side.

If you use the circuit board, begin construction by installing the six wire jumpers on the top (component side) of the circuit board that are necessary to complete some circuit paths.

Use solid bare hook-up wire or cut-off resistor leads for the short jumpers, and insulated solid hook-up wire for the long ones. These wire jumpers are indicated in the wiring guide in Figure 5.

Three of these wire jumpers are located just below and parallel to resistor R4. A wire jumper is located immediately to the left of capacitor C14, and just below it is another wire jumper to the left of and parallel to IC3. The remaining jumper is immediately to the right of capacitor C13. Then install the sockets for the DIP ICs.

If you wire wrap the circuit, arrange and orient the components in a manner similar to that in the wiring guide in Figure 5. Whichever method of construction you use, do not plug the ICs into

their sockets until after you've conducted preliminary voltage tests.

After mounting the IC sockets, install and solder into place the voltage regulator VR1, the diodes, resistors, resistor networks, capacitors, crystal, and header pins.

Make certain before you solder any leads to the copper pads on the bottom of the board that the electrolytic capacitors, the resistor networks, and diodes are properly oriented.

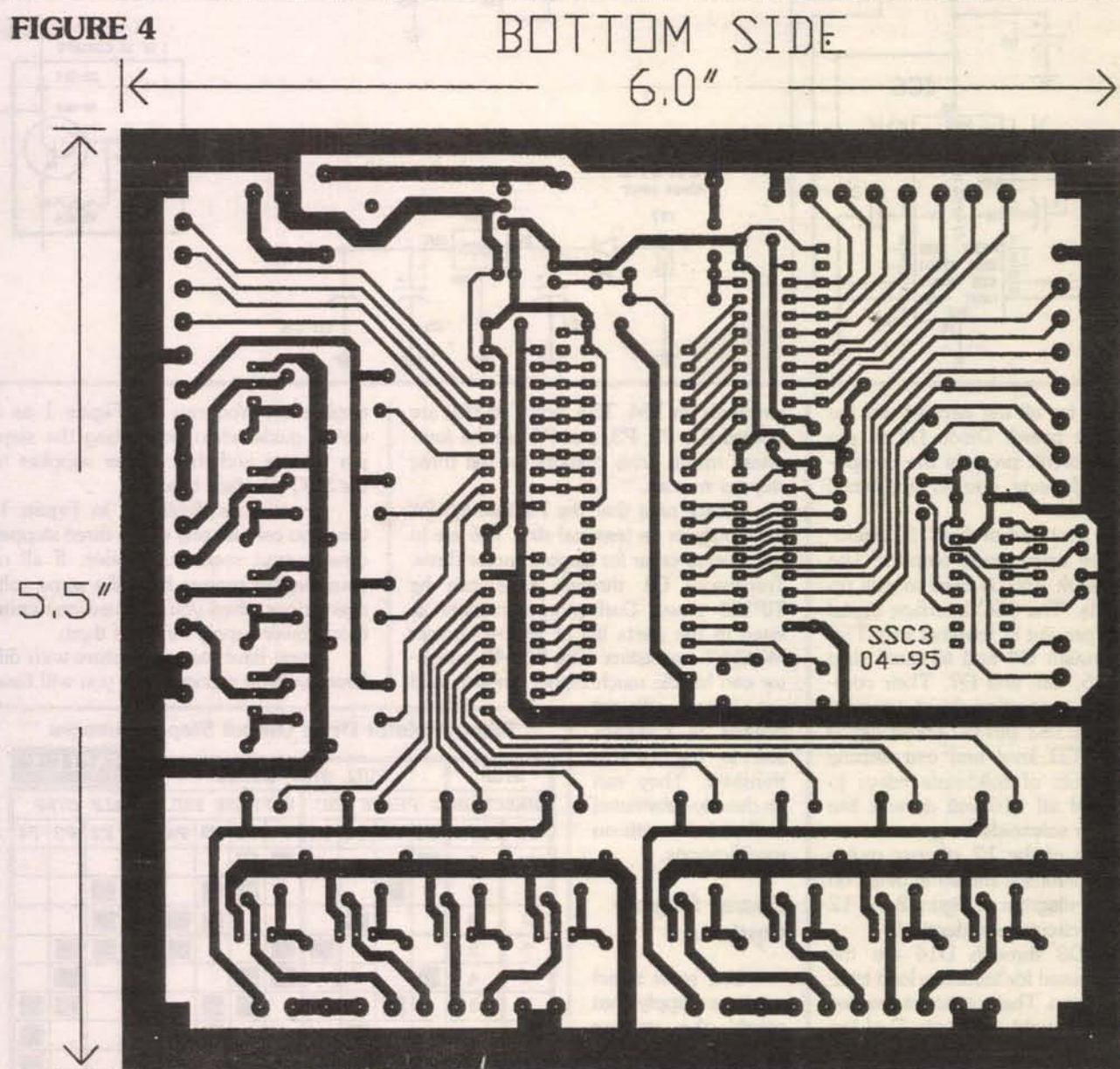
Use double-sided foam mounting tape to secure the crystal Y1 to the surface of the board. Then mount the screw terminal strips TS1 through TS7. Install power transistors Q1 through Q12 last. These power transistors may or may not need to be heatsinked. This will depend mainly on the power they have to dissipate with the particular stepper motors that you choose for your application.

The TIP120 transistors get too hot if they have to sink a constant 0.5 amps or more of current. Heatsinks are highly recommended in this case.

The IRF540 power MOSFET transistors stay room temperature without heatsinks when sinking a constant 1.0 amps of current. They are more expensive and require precautionary measures to protect them against damage due to electrostatic discharge when being handled.

You can use any type of enclosure that will comfortably accommodate the

**FIGURE 4**





circuit board assembly and the power supplies for the circuit board and stepper motors. Before actually mounting the circuit board assembly inside the enclosure, double-check all component installations (except for the DIP ICs, which should not be installed at this time) for appropriate values or types and orientations.

When you are satisfied that all component installations are correct, turn over the circuit board assembly and carefully examine it for missed solder connections, poorly soldered connections, and inadvertent solder bridges, especially between closely-spaced IC pads and conductors.

Solder any missed connections and reflow the solder on any connection that appears suspicious. Use desoldering braid or a vacuum-type desoldering tool to remove any solder bridges located.

When you're certain that the circuit is properly wired and soldered, mount it inside the enclosure using .5 inch metal spacers and 4-40 machine hardware. Then prepare the cable that interconnects the project to your computer. Your PC will have either a 9- or 25-pin serial port connector. Use Figure 6 as a guide when fabricating one of the two possible types of cables needed for interconnecting to your PC's serial port.

## Initial Checkout

A DC voltmeter or a multimeter set

to the DC-volts function is the only test instrument you need to check out the project. Clip the common lead to a suitable circuit ground point, such as one of the mounting holes at the corners of the circuit board.

With no ICs installed in the sockets and the interface cable not connected from your PC, power up the circuit via TS7. Make certain that you properly polarize the connections.

With power applied to the project, touch the "hot" probe of the meter to each of the IC1 through IC6 Vcc socket pins. You should obtain a reading of +5 volts in all cases. If you fail to obtain the power reading at any one or more points in the circuit, power down and rectify the problem. Check to make sure that all components are in their correct locations and are properly oriented, and make sure that all components are soldered into place.

Once you obtain the proper readings, power down the circuit and allow the charges to bleed off the electrolytic capacitors. Then plug the ICs into their respective sockets. Make sure each is in its proper socket and is properly oriented and that no pins overhang the sockets or fold under between the IC's ad sockets.

## Command Summary

There are 14 commands in the SSC

system. The lower four bits of the command byte (bits 0 through 3) contain the actual command. Most of the commands use bits 4, 5, and 6 of the command byte as flags corresponding to stepper motors 1, 2, and 3, respectively.

Some commands like the start and stop commands only take action if the stepper flag is set. Other commands like the change direction and auto drive enable commands take action with both possible logic states of the flags.

The upper nibble of the command byte (bits 4 through 7) is used to indicate the digital I/O number for the read digital input and change digital output commands. Commands 1, 2, and 3 are initialization commands and must be sent first before any system outputs are enabled. These commands can be sent in any order.

### Command 1 ... Initialize for full or half step

Full or half step mode is initialized for all three stepper motors simultaneously with this command. Bits 4, 5, and 6 of this command byte are the stepper flags. A flag is cleared for full step mode and set for half step mode. See Table 1 for the stepper motor drive output step sequences for these modes.

### Command 2 ... Initialize stepper limit sense

Limit sense is initialized for all three stepper motors simultaneously with this command. Bits 4, 5, and 6 of this command byte are the stepper flags. A flag is cleared if limit sense is not used and set if limit sense is used.

The mechanical limit sense inputs are digital inputs I1 through I6. They are labeled on the schematic diagram in Figure 2 and listed on the wiring guide in Figure 5 as CCW1 and CW1 for stepper 1, CCW2 and CW2 for stepper 2, CCW3 and CW3 for stepper 3.

The state of these six digital inputs can always be read with command 12, the read digital input command. When the limit sense is initialized for a stepper motor, the SSC interface will immediately stop stepper motion when a limit input goes to a high logic state.

The stepper motor can be moved away from the limit by reversing its direction. All digital inputs are pulled high with a 10K ohm resistor, a normally closed switch on the input terminal to ground is all that is needed.

### Command 3 ... Initialize for one or two phase excitation

One or two phase excitation mode is initialized for all three stepper motors simultaneously with this command. There are three possible modes of operation that a stepper motor can be initialized to. They are: full step with one phase excitation; full step with two phase excitation; and half step.

Bits 4, 5, and 6 of this command byte are the stepper flags. A flag is cleared for one phase excitation mode and set for two phase excitation mode. The state of the stepper flag in this command is ignored if a stepper motor is initialized for half step operation with command 1. See Table 1 for the stepper motor drive output step sequences for these modes.

### Command 4 ... Change the step rate clock

This command changes the step rate clock which is the time base generator for the stepper motors. Changing the step rate clock affects the speed of all three stepper motors. The SSC interface will ignore the step rate clock command if any of the steppers are in motion when the command is received. The step rate clock range setting is from 1 to 240 decimal.

Table 2 indicates the most popular step rate clock settings and frequencies. A default step rate clock setting of 199 (502 Hz) is selected when the SSC interface is initialized. The slowest step rate clock setting is 1. A value of 1 is set if a step rate clock setting of 0 is received. A value of 240 is set if a value larger than 240 is received.

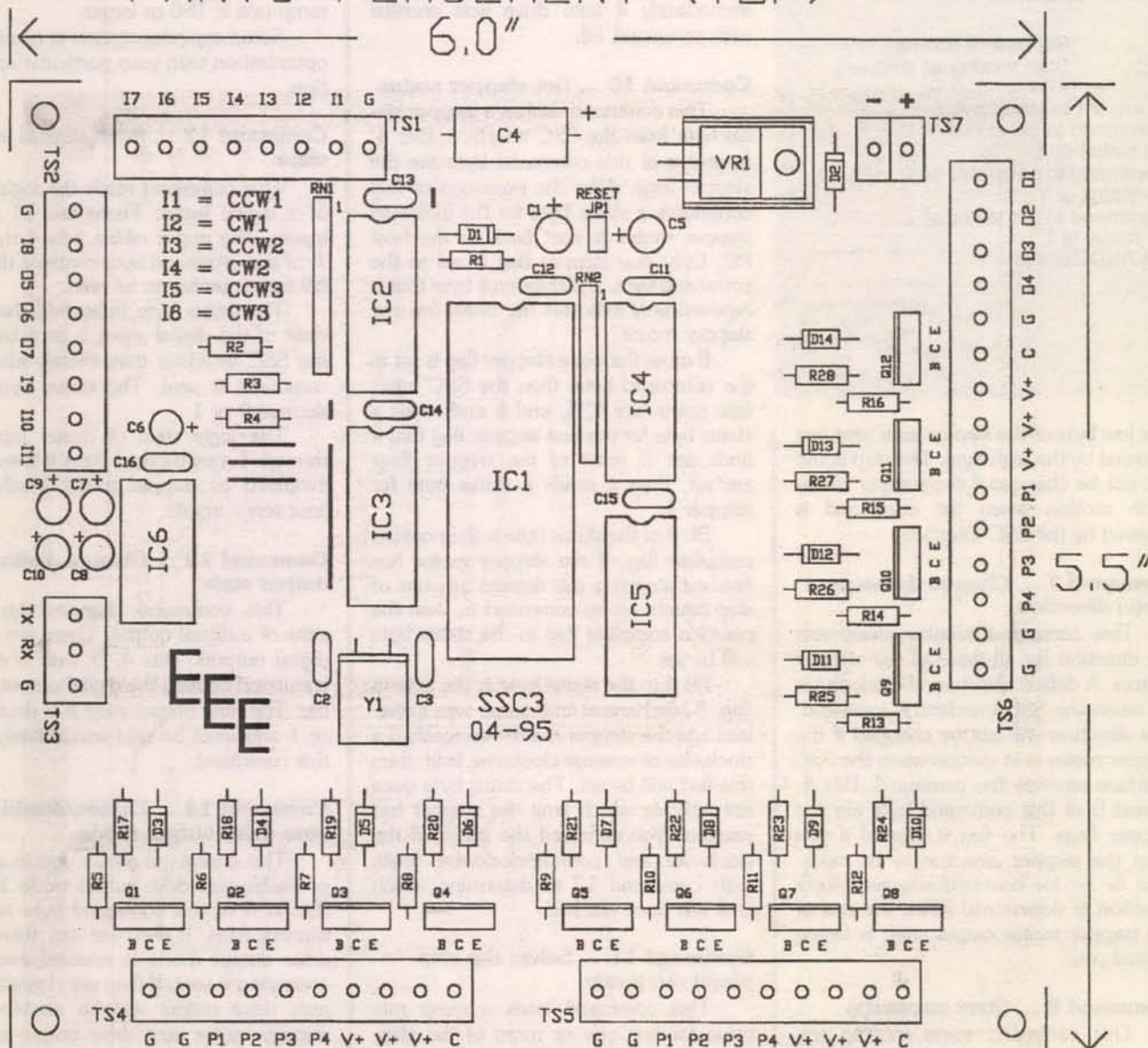
There are no flags associated with this command. The upper nibble in the command byte is not used. The step rate clock byte must be sent immediately following this command.

### Command 5 ... Load the speed divisor(s)

This command allows you to change any one or more stepper motor speeds by a given step rate clock division. The speed divisor range is from 1 to 255. The SSC interface will set the speed divisor to

## PARTS PLACEMENT (TOP)

FIGURE 5





# LISTING 1. A Simple Stepper Motor Exerciser Program

```

CONST SetX = 16, SetY = 32, SetZ = 64 ' Define constants
CONST XCW = 0, XCCW = 16, YCW = 0, YCCW = 32, ZCW = 0, ZCCW = 64

CLS : OPEN "COM2:9600,N,8,1" FOR RANDOM AS #1 ' Initialize communications

DO UNTIL EOF(1)
    I = ASC(INPUT$(1, #1))
    LOOP
    ' Do not start communications
    ' until the serial port
    ' input buffer is empty.

PRINT #1, CHR$(SetZ + 1); ' X and Y = full step, Z = half step
PRINT #1, CHR$(2); ' No limit sense for any steppers
PRINT #1, CHR$(SetY + 3); ' Y = 2 phase excitation
PRINT #1, CHR$(4); ' Set a step rate
PRINT #1, CHR$(160); ' clock of 160
PRINT #1, CHR$(SetX + 5); ' Set the speed divisor for
PRINT #1, CHR$(5); ' stepper X to 5
PRINT #1, CHR$(SetY + 5); ' Set the speed divisor for
PRINT #1, CHR$(10); ' stepper Y to 10
PRINT #1, CHR$(SetZ + 5); ' Set the speed divisor for
PRINT #1, CHR$(15); ' stepper Z to 15

Direction = 0

DO ' Loop forever! End program with control break

    Steps% = 500 ' Step count of 500
    addr = VARPTR(Steps%)
    LoSteps = PEEK(addr) ' Split the step count
    HiSteps = PEEK(addr + 1) ' into the low and high
    PRINT #1, CHR$(SetX + SetY + SetZ + 6); ' bytes here
    PRINT #1, CHR$(LoSteps); ' Send command
    PRINT #1, CHR$(HiSteps); ' Send Low byte
    PRINT #1, CHR$(HiSteps); ' Send High byte

    IF Direction = 0 THEN ' Change direction variables
        Xdir = XCW
        Ydir = YCCW
        Zdir = ZCW
    ELSE
        Xdir = XCCW
        Ydir = YCW
        Zdir = ZCCW
    END IF

    PRINT #1, CHR$(Xdir + Ydir + Zdir + 7); ' Set new directions
    PRINT #1, CHR$(SetX + SetY + SetZ + 8); ' Start moving all steppers

    DO ' Loop until all position complete flags are set in status bytes
        PRINT #1, CHR$(SetX + 10); ' Send command to get status of X
        Xstatus = ASC(INPUT$(1, #1)) ' Receive status of X
        PRINT #1, CHR$(SetY + 10); ' Send command to get status of Y
        Ystatus = ASC(INPUT$(1, #1)) ' Receive status of Y
        PRINT #1, CHR$(SetZ + 10); ' Send command to get status of Z
        Zstatus = ASC(INPUT$(1, #1)) ' Receive status of Z
        LOOP UNTIL Xstatus = 1 AND Ystatus = 1 AND Zstatus = 1

    Direction = Direction + 1
    IF Direction = 2 THEN Direction = 0
LOOP
END

```

1 if it receives a speed divisor of 0. A speed divisor setting of 1 will cause the step rate to be equal to the current setting of the step rate clock.

A speed divisor setting of 2 will cause a step rate of one half the speed of the step rate clock setting and so on, up to a maximum division of 255. A default speed divisor of 10 is set for all steppers when the SSC interface is initialized.

Speed divisors can be changed while the stepper motors are in motion. Bits 4, 5, and 6 of this command byte are the stepper flags. The flag is set if the stepper is to receive the speed divisor. The speed divisor byte must be sent immediately after this command.

## Command 6 ... Load the step count

This command loads the step count for any one or more stepper motors. The step count is a 16-bit word with a range of 1 to 65535. Bits 4, 5, and 6 of this command byte are the stepper flags. The flag is set if the stepper is to receive the step count. The two-byte step count must be sent immediately after this command.

The low byte of the step count is sent first followed by the high byte. The step count will not be changed if the stepper motor is in motion when the command is received by the SSC interface.

## Command 7 ... Change the stepper(s) direction

This command simultaneously sets the direction for all three of the stepper motors. A default direction of clockwise is set when the SSC interface is initialized. The direction will not be changed if the stepper motor is in motion when the SSC interface receives the command. Bits 4, 5, and 6 of this command byte are the stepper flags. The flag is cleared if you want the stepper direction to be clockwise or set for counterclockwise. Motor direction is determined when the end of the stepper motor output shaft is facing toward you.

## Command 8 ... Start stepper(s)

This command starts moving any one or more steppers. Bits 4, 5, and 6 of this command byte are the stepper flags.

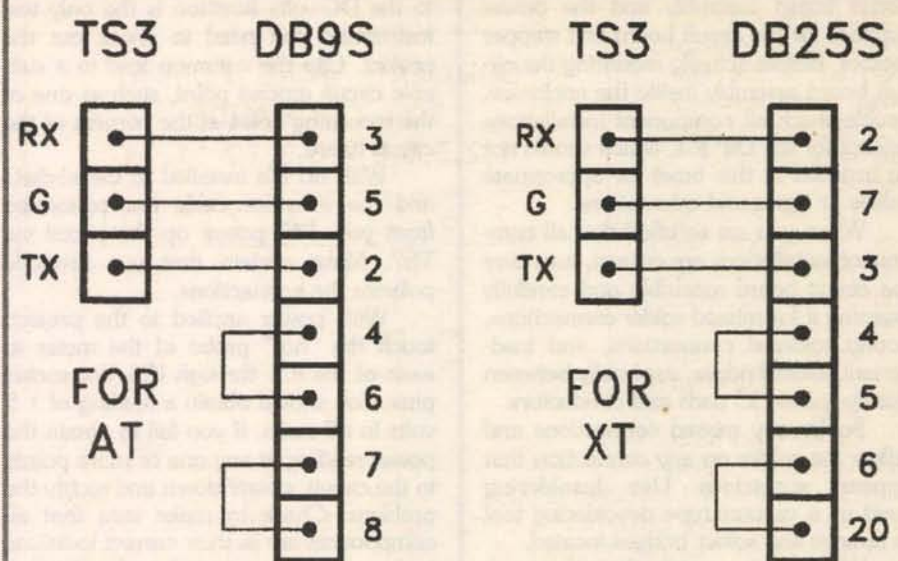


Figure 6. Interface cable wiring details.

If a flag is set and there are step counts remaining, then the stepper will start moving after the execution of this command.

## Command 9 ... Stop stepper(s)

This command stops moving any one or more steppers. Bits 4, 5, and 6 of this command byte are the stepper flags. If a flag is set, then the stepper motor will stop after the execution of this command. The motor will stop immediately regardless of the ramp rate set with command 11 and the drive outputs will turn off immediately if auto drive was enabled with command 14.

## Command 10 ... Get stepper status

This command fetches a stepper status byte from the SSC interface. Bits 4, 5, and 6 of this command byte are the stepper flags. After the execution of this command, a status byte for the indicated stepper motor is sent back to the host PC. Only one stepper flag is set in the command byte, and the status byte that is received only indicates the status for one stepper motor.

If more than one stepper flag is set in the command byte, then the SSC interface scans bits 4, 5, and 6 and sends a status byte for the first stepper flag that it finds set. If none of the stepper flags are set, then it sends a status byte for stepper 1.

Bit 0 of the status byte is the position complete flag. If the stepper motor has finished stepping the desired amount of step counts set by command 6, then the position complete flag in the status byte will be set.

Bit 4 in the status byte is the at-limit flag. If mechanical limit sense was initialized and the stepper motor has reached a clockwise or counter-clockwise limit, then this flag will be set. The status byte does not indicate which limit the stepper has reached. You can read the states of the clockwise and counter-clockwise limits with command 12 to determine which limit has been reached.

## Command 11 ... Select the stepper(s) ramp rate

This command loads a ramp rate value for any one or more of the steppers. The ramp rate range is from 0 to 255 decimal.

A default ramp rate of 0 is set when the SSC interface is initialized. Bits 4, 5, and 6 of this command byte are the stepper flags. The ramp rate value must be sent immediately after this command.

The ramp rate value modifies the stepper's speed divisor and is non-linear for this reason. It modifies the speed divisor for up to 255 of the first and last steps of the step count. It provides a means of ramping the acceleration and deceleration of the stepper's speed. It seems to work best when the stepper speed divisor is set at a value of 7 or larger, and the ramp rate is 150 or larger.

Some experimentation is needed for optimization with your particular application.

## Command 12 ... Read digital input state

This command reads the logic state of a digital input. There are 11 digital inputs. The upper nibble (bits 4 through 7) of the command byte contains the digital input number to be read.

The status byte indicating the logic state of the digital input is sent back by the SSC interface immediately after the command is sent. The status byte is a decimal 0 or 1.

The logic state of digital inputs 1 through 6 can be read even if they were initialized as stepper motor mechanical limit sense inputs.

## Command 13 ... Change digital output state

This command changes the logic state of a digital output. There are seven digital outputs. Bits 4, 5, and 6 of this command contain the digital output number. The new output state is a decimal 0 or 1 and must be sent immediately after this command.

## Command 14 ... Enable/disable auto drive output mode

This command allows you to enable or disable auto drive output mode. Bits 4, 5, and 6 of this command byte are the stepper flags. If they are set, then auto drive output mode is enabled after the command is sent. If they are cleared, then auto drive output will be disabled. All stepper motor auto drive output modes are simultaneously affected by this command. These flags are cleared at system



reset. If auto drive output mode is enabled, then all of the four-phase motor drive outputs will turn off when the stepper motor is stopped.

Turning off a stepper motor's drive outputs when it is stopped will prevent unnecessary current drain on the power supply and overheating of the stepper motor.

On the other hand, the stepper motor drive outputs may need to be enabled in order to provide a locking torque which will hold the stepper motor at its rest position.

Locking torque may not be necessary in situations where the steps-per-inch ratio of the positioning system is very high or when it is not important to maintain an absolute rest position.

The motor drive outputs will turn on one step time before the stepper motor is sent into motion and they will remain on for one step time after the motor has finished stepping.

The stepper motor's position complete flag in the status byte fetched with command 10 will be set the instant the motor drive outputs are turned off. If auto drive output mode is disabled, then the stepper motor's drive outputs will never be turned off.

You can enable or disable auto drive output mode at any time.

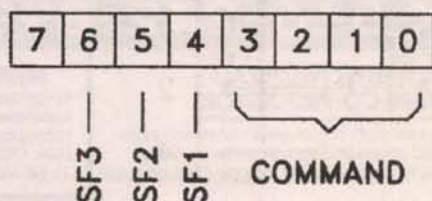
Enabling or disabling auto drive output mode for a stepper motor when it is stopped will instantly turn on or off its drive outputs. Enabling or disabling auto drive output mode while a stepper motor is in motion will have no effect until it stops.

You can enable auto drive output mode before you finish initializing the system with commands 1, 2, and 3 if you want the stepper motor drive outputs to be off after the system is initialized.

The SSC interface can be reset by sending the two byte sequence of decimal 80 and 95. A decimal 5 is sent back by the SSC interface to confirm the reset.

The SSC interface will except and execute all of the commands before system initialization has been completed. However, motor drive outputs and digital

### COMMAND WORD FORMAT FOR COMMANDS 1,2,3,5,6,7,8,9,10,11,14



### COMMAND WORD FORMAT FOR COMMANDS 12 AND 13

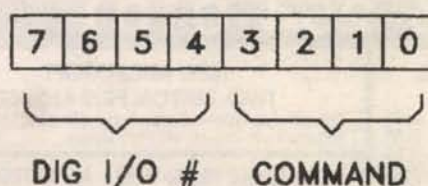


Figure 7. Command word formats.

outputs will be at logic low states. You can set up various parameters like the step rate clock, the speed divisors, auto drive enable, mode, and load step counts before you send commands 1, 2, and 3 for final initialization.

The example QuickBasic program of Listing 1 utilizes nine of the SSC systems commands. It is intended to illustrate how easy it is to command and control three stepper motors. It can be used as a test generator when you are trying to determine the proper phase connections of surplus or salvaged stepper motors. Other more detailed programs are offered in support of this project in the note at the end of the Parts List.

Constants are defined at the beginning of the program assigning names to numbers in order to simplify things. The serial port is initialized for the SSC interfaces fixed communications parameters. The serial port input buffer is flushed of any unwanted characters before any communications takes place.

The program names stepper motors 1, 2, and 3 as X, Y, and Z, respectively. Stepper motor X is initialized for full step one phase excitation mode. Stepper motor Y is initialized for full step two phase excitation mode. Stepper motor Z is initialized for half step mode.

No limit sense is initialized because it is the assumption that the stepper motors are under test and will not be mechanically coupled to anything. The step rate clock is set at 160 (300 HZ).

A different speed divisor is set for each stepper motor. After setting up all the necessary parameters, the program loops continuously stepping all three of the stepper motors 500 steps in one direction and then the other.

Since all three steppers use different speed divisors, stepper X will stop first followed by stepper Y and then stepper Z. Steppers X and Y will wait for stepper Z before reversing direction. The direction of stepper Y is always the opposite of steppers X and Z.

The program illustrates how you can keep track of each stepper motor's direction by defining the direction flag constants at the beginning of the program.

### Tips for Salvaged Motors

The typical four-phase unipolar stepper motor has six wires. As shown in the SSC system interconnect drawing of Figure 1, these stepper motors have two separate center tapped coils.

I have found some four-phase stepper motors that have five wires. These stepper motors had their center taps joined together inside the motor.

If you follow this simple procedure, you can get any six wire four-phase stepper motor rotating in just a few minutes.

With your volt/ohm meter on a low ohms setting, find the two separate coils and their center tapped wires. Connect the wires at the center tap of each coil to the stepper motor power supply positive output V+ terminals on the interface PC board.

The two remaining wires of one coil are stepper phases one and three. The two remaining wires of the other coil are stepper phases two and four. Pick either one of the coils and hook the two wires up to the P1 and P3 output terminals of the SSC interface circuit board. Take the two wires from the other coil and connect them to the P2 and P4 terminals.

At this point, the motor should

rotate, so give it a try! If the direction of rotation is the opposite that it is supposed to be, then reverse the wires on terminals P1 and P3, or reverse the wires on terminals P2 and P4, but not both.

Label your wires! If this procedure does not produce a smoothly rotating motor, then you may have problems with the interface circuitry, the power supply, or perhaps you are trying to step the motor too fast.

This procedure will get your stepper motor stepping even though the wires attached to terminals P1 through P4 may not necessarily be what the manufacturer states are the proper connections. The motor will step properly either way.

### In Closing

Although this project was designed primarily for use with IBM PC/XT/AT and compatible computers, the SSC interface can be used with any computer that has an RS-232 serial port configured for 9600 baud, eight bit, no parity, and one stop bit. Any programming language can be used for software application development. You should know that the Standard edition of Visual Basic for Windows does not include any means of utilizing a serial port. You must learn the windows API (Application Programmers Interface) in order to access the serial port with the standard edition.

The windows API is a large library of functions that are not documented in the Visual Basic for Windows Reference manuals. The professional edition of Visual Basic for Windows supports the serial port and there is no need to learn the API.

So on to the next projects! These will include mastering Visual Basic for Windows. Your comments and questions are invited. You can contact me by E-Mail at: deggert1@athenet.net NV

The binary file and software example programs mentioned in this article are available at the Nuts & Volts Web Site. See file SSCDISK.EXE in the FTP Code Library.  
<http://www.nutsvolts.com>

## ● ● ● PARTS LIST

### Semiconductors

D1 - 1N914 small signal diode  
D2 - 1N4004 silicon rectifier diode  
D3 thru D14 - 1N4007 silicon rectified diode  
IC1 - 8751 or 87C51 12-MHz embedded controller  
IC2 thru IC5 - 74HC541 octal buffer  
IC6 - MAX232 dual RS-232 interface  
Q1 thru Q12 - TIP120 power Darlington transistor  
VR1 - 7805 +5 volt fixed regulator

### Capacitors

C1,C6,C7,C8,C9,C10 - 10 uF @ 35V radial lead electrolytic  
C2,C3 - 22 pF ceramic disk  
C4 - 4.7 uF @ 35V radial lead electrolytic  
C5 - 47 uF @ 35V axial lead electrolytic  
C11 thru C16 - .1 uF monolithic

### Resistors (1/4 watt, 5% tolerance)

R1,R2,R3,R4 - 10,000 ohms  
R5 thru R16 - 47,000 ohms

R17 thru R28 - 1,000 ohms  
RN1,RN2 - 9 x 10,000-ohm single-row resistor network (Digi-Key Cat. No. 770-101-R10K or similar)

### Miscellaneous

Y1 - 11.0592 MHz crystal HC18/U crystal (Digi-Key Cat. No. X078 or similar)  
TS1 thru TS7 - 25 each two-position PC mount screw terminal (Digi-Key Cat. No. ED1601 or similar) and two each three-position PC mount screw terminal (Digi-Key Cat. No. ED1602 or similar)  
J1 - 2 pin single row header  
Printed circuit board or perforated board with holes on 0.1" centers and suitable wire wrap hardware (see text); sockets for all DIP ICs; suitable enclosure (see text); heatsinks for VR1 and Q1 through Q12 (optional for Q1 through Q12 - see text); 4 x 40 hardware; hook-up wire; solder; etc.

Note: The following items are available from Dan Eggert, 25 Kensington Ct., Appleton, WI 54915: Single-sided printed circuit board with parts layout silk-screened on top side, \$15.00; 8751 programmed with SSC system, \$20.00; 11.0592-MHz crystal, \$2.00.

Also available are: kit with all circuit board components including programmed 8751, printed circuit board, and terminal strips, \$95.00; A floppy disk containing a binary file for programming your own 8751, stepper motor exerciser programs written in GWBASIC and QuickBasic, and a drilling application program written in QuickBasic, \$5.00. For diskettes, specify 3 1/2" or 5 1/4" format. Add 3.5% of total order for shipping (minimum \$2.50). Wisconsin residents, please add 5% sales tax.

### Component Sources

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80387SX-20	\$17.95	8751H	\$9.95
80387SX-25	\$19.95	8752	\$13.95
80387DX-20	\$17.95	8755	\$6.95
80387DX-25	\$24.95	MC68020RC20	\$14.95
80486SX-25 (PGA)	\$14.95	MC68020RC33E	\$19.95
AM486DX-33 (PGA)	\$17.95	MC68030RC25	\$24.95
80486DX-50 (PGA)	\$19.95	MC68030RC33	\$29.95
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8742	\$4.95	MC68882RC25	\$14.95
8748	\$4.95		

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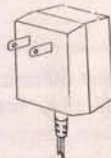
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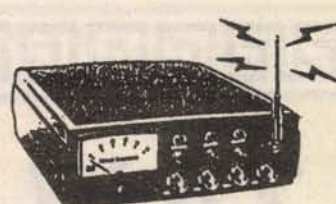
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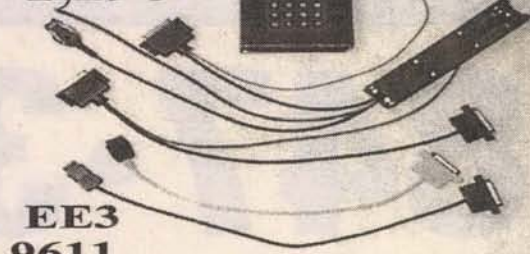
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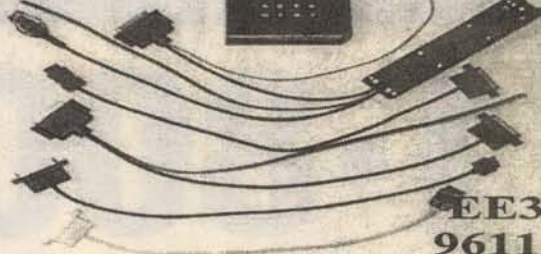
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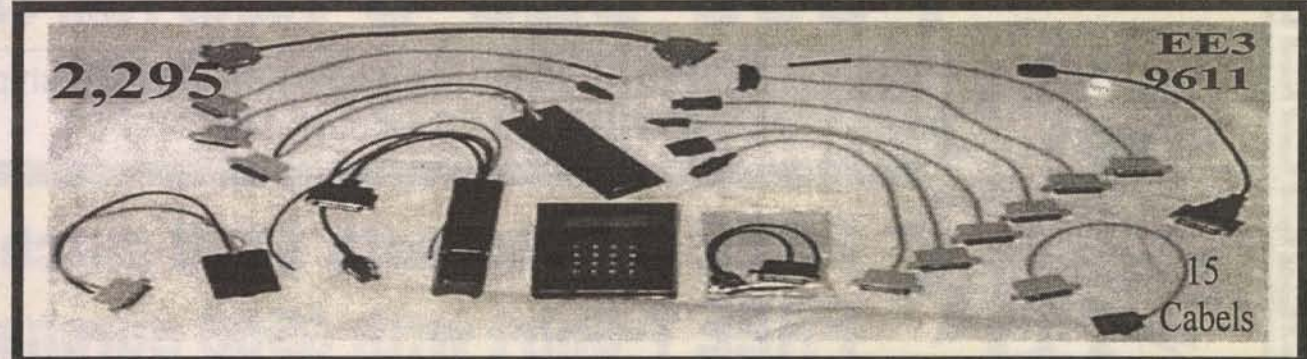
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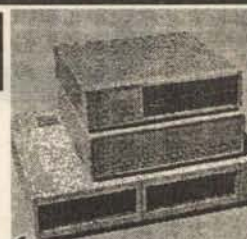
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## An Inexpensive Home Security Camera Switcher

by George Cole

**M**any home security set-ups employ low-cost surveillance cameras to allow for visual monitoring of critical access ways or areas around the grounds. An inexpensive circuit has been constructed that allows for the sequential switching of up to eight cameras, while giving a numeric readout of which view is being presented on the output of the circuit.

The key element in this circuit is the Maxim MAX455 video multiplexer integrated circuit (U1). This IC operates from a  $\pm 5$ -volt DC supply and is easily controlled by applying a three-bit binary code to its three address lines.

For all practical purposes,

switching time between sources is instantaneous. The IC also has a built-in cable line driver video amplifier capable of easily driving a 75-ohm cable arrangement.

This circuit is readily available on the market and costs around \$20.00, depending on your source of supply. It is a wideband, stable device with exceptional operational characteristics, and makes an ideal solution for multiple input switching of wideband signals.

An input signal is connected to the line driver video amplifier when the address corresponding to it is placed on the pins A0, A1, and A2. Thus, for input 0 to be connected to the output, A0, A1, and A2 must all be at logical 0. Likewise, for

be eliminated from the circuit and replaced with shorts.

Too much DC offset applied to the inputs of the MAX455 will cause the device to saturate in one direction or the other, resulting in distortion of the video signal or its sync tip, and unsymmetrical current drain in the amplifier.

The 22K resistors to ground on the input pins provide termination for the input circuits of the IC. Matching from the output driver to a standard 75-ohm video cable is provided via the 75-ohm resistor in series with the output connector. The amplifier voltage gain is set to 2 by the network of two 1.15K resistors and the line from the junction of the two back to the inverting input of the amplifier.

This set-up provides non-inverting amplification of the applied signal. The value of the signal at the output pin of the 455 will always be twice that of the input. When driving a 75-ohm cable with a termination of 75 ohms, the signal value at the output connector will be the same as the input.

The generation of the timing and control signals for the address lines is developed starting with the oscillator circuit built around the NE555 timer IC (U4). This is a versatile timer chip which has been connected, in this case, to provide a variable frequency rectangular wave as a clock for the counter circuit (74HC4040, U2).

The frequency of operation is set by the resistor/capacitor combination of R12, 13, 14, and C9. Using a 1M variable resistor for R12, results in a wide range of

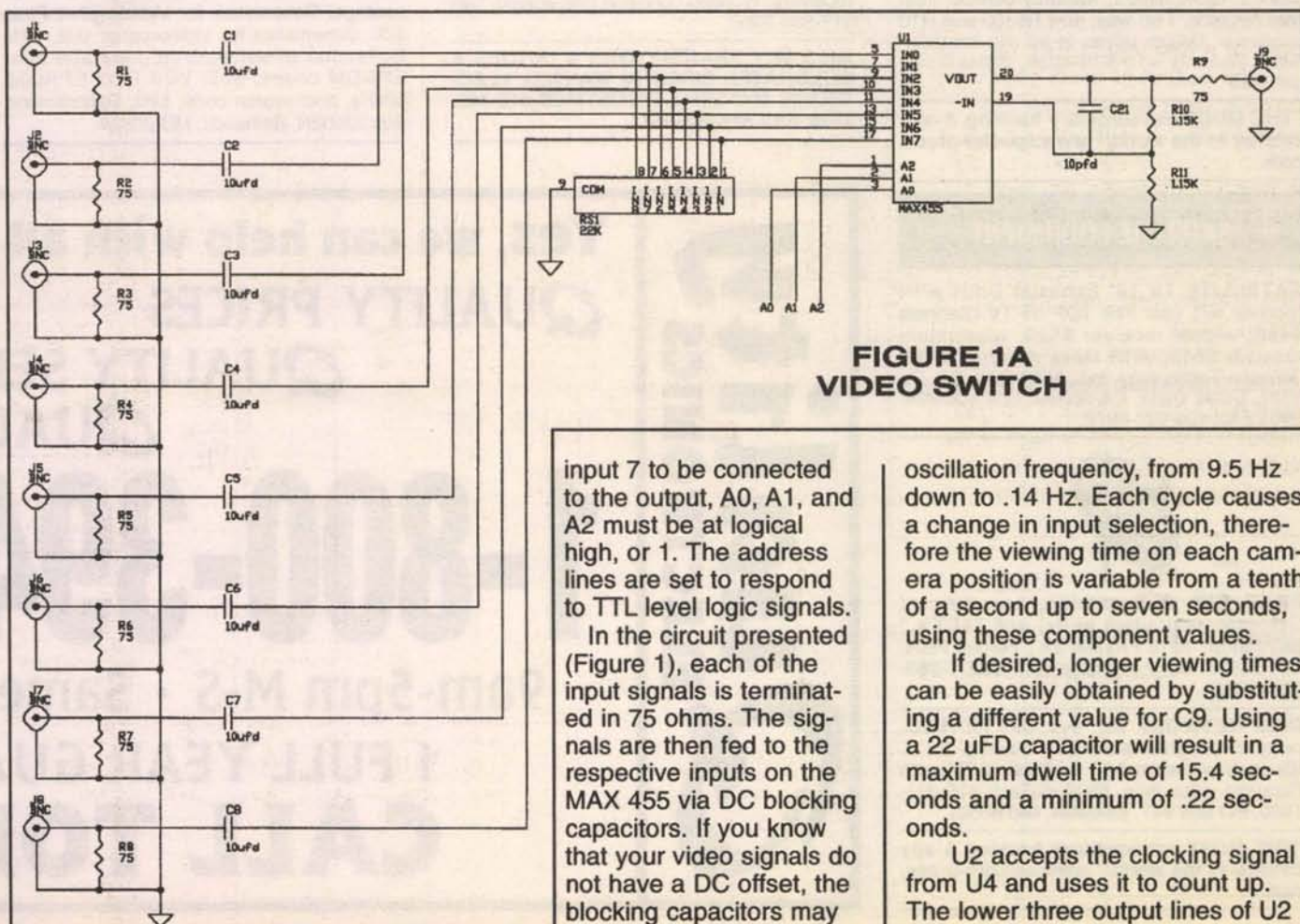


FIGURE 1A  
VIDEO SWITCH

input 7 to be connected to the output, A0, A1, and A2 must be at logical high, or 1. The address lines are set to respond to TTL level logic signals.

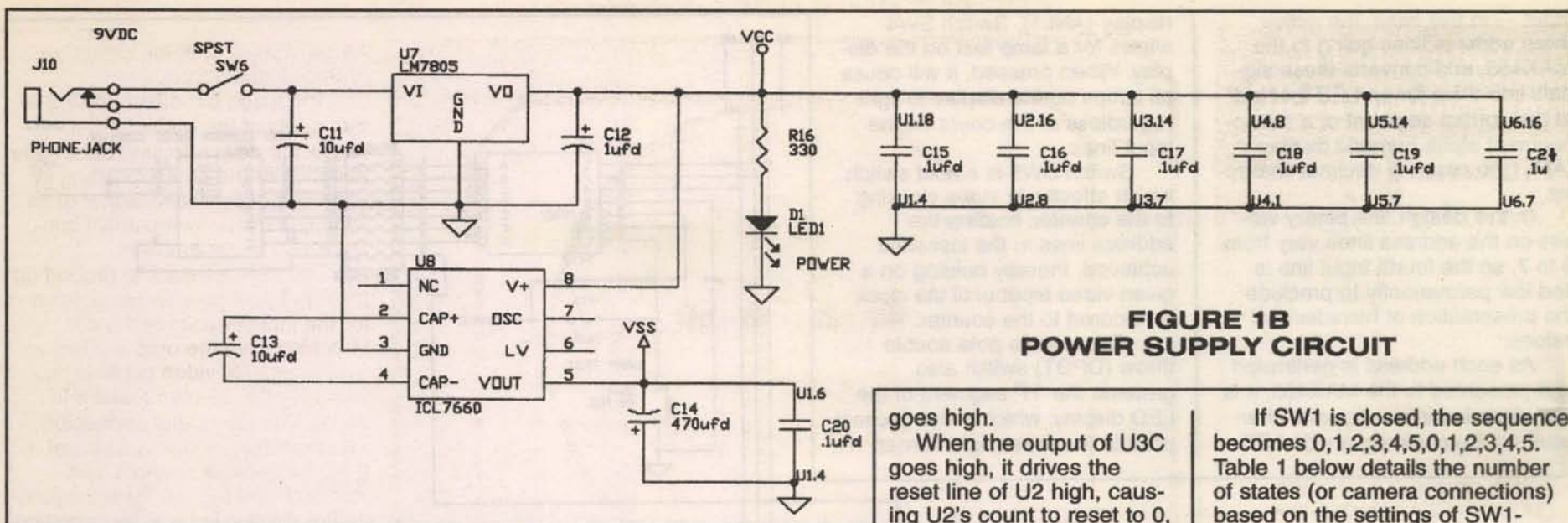
In the circuit presented (Figure 1), each of the input signals is terminated in 75 ohms. The signals are then fed to the respective inputs on the MAX 455 via DC blocking capacitors. If you know that your video signals do not have a DC offset, the blocking capacitors may

oscillation frequency, from 9.5 Hz down to .14 Hz. Each cycle causes a change in input selection, therefore the viewing time on each camera position is variable from a tenth of a second up to seven seconds, using these component values.

If desired, longer viewing times can be easily obtained by substituting a different value for C9. Using a 22 uFD capacitor will result in a maximum dwell time of 15.4 seconds and a minimum of .22 seconds.

U2 accepts the clocking signal from U4 and uses it to count up. The lower three output lines of U2





are tied to the three address lines on the MAX455. As the count value changes, the output of the MAX455 is progressively connected to each of the inputs 0 through 7. If all we wanted to do was provide for a fixed sequence of switching, we could stop the design at this point

I have carried the design a step further to allow the user to be able to connect to fewer inputs than the full eight. The fixed sequencer, if not modified, will spend the same amount of time on each input address. Thus, if only four inputs were used, half of the sequencing time would be spent on no signal inputs resulting in blank screens.

The logic circuit made up of the 74LS11 (U3), the 74LS32 (U5), and the three switches (SW1-SW3), allows us to "set the count" for the sequencer; in effect, shortening the count from the native 0 to 7. The output of each address line from U2 is connected to one input of a two input OR gate.

The output of each gate will be logically high when either the address line is high, or when the switch pulls the second line high, or when both inputs are high. In this fashion, the effect of a particular address line may be suspended by pulling the switched input high, thus always rendering that gate's output high.

The output of each gate is connected to one input of a three-input AND gate (U3A). This gate's output will go logically high when all three inputs are high. The output of this gate is tied, in turn, to

one of three inputs of another AND gate (U3C). One of the inputs to U3C is tied high (effectively not used) and one input is tied to the output of U5D. U5D develops a high state when bit Q4 of U2 goes high, or when the output of Q1

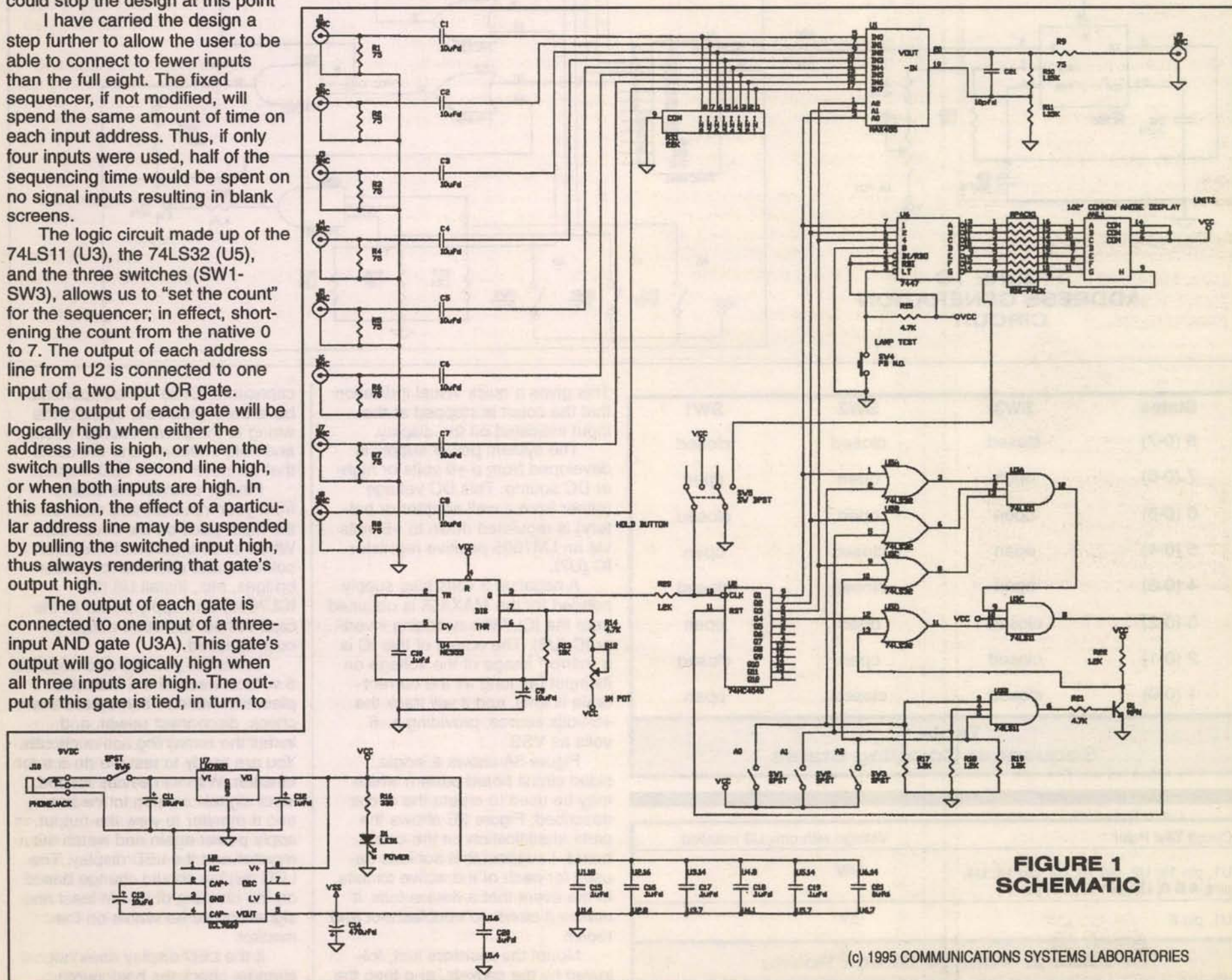
from the initial state. Thus, if SW2 is closed, pulling its input line high, reset will occur when a count of five has been reached (representing five allowable states, 0 to 4), limiting the sequence to 0,1,2,3,4,0,1,2,3,4.

goes high.

When the output of U3C goes high, it drives the reset line of U2 high, causing U2's count to reset to 0, starting the sequence over

If SW1 is closed, the sequence becomes 0,1,2,3,4,5,0,1,2,3,4,5. Table 1 below details the number of states (or camera connections) based on the settings of SW1-SW3.

The circuit also contains a direct readout capability to allow the user to easily identify the input signal being viewed. This is the 7447 binary to seven segment display driver/converter IC. This device accepts a four-bit binary









position. If all is working properly, you should be stepping through all eight outputs (assuming SW1, SW2, SW3 are closed), and the LED display should be changing with each camera position to reflect the input channel number from 0 to 7.

Physical packaging for our prototype was done using a Radio Shack metal enclosure (Catalog #270-274A). This case was 3-1/16" x 8-1/4" x 6-1/8" and provided adequate space for the mounting of the input and output video connectors, front panel controls and displays, and the circuit board, without undue effort. A smaller package could easily be developed if necessary.

Figure 2A depicts a suggested legend pattern for the unit using this case. Figure 2B provides a detailed view of the front and back layout dimensions. Note that, if you decide to use an RCA jack instead of a BNC, the drill hole size for the video connectors will need to be reduced to 1/4". We used Superglue™ to hold the LED display in position; some other method may be more suitable for your construction. If possible, a red lens should be placed over the display as this enhances the digits in unobtruded lighting. NV

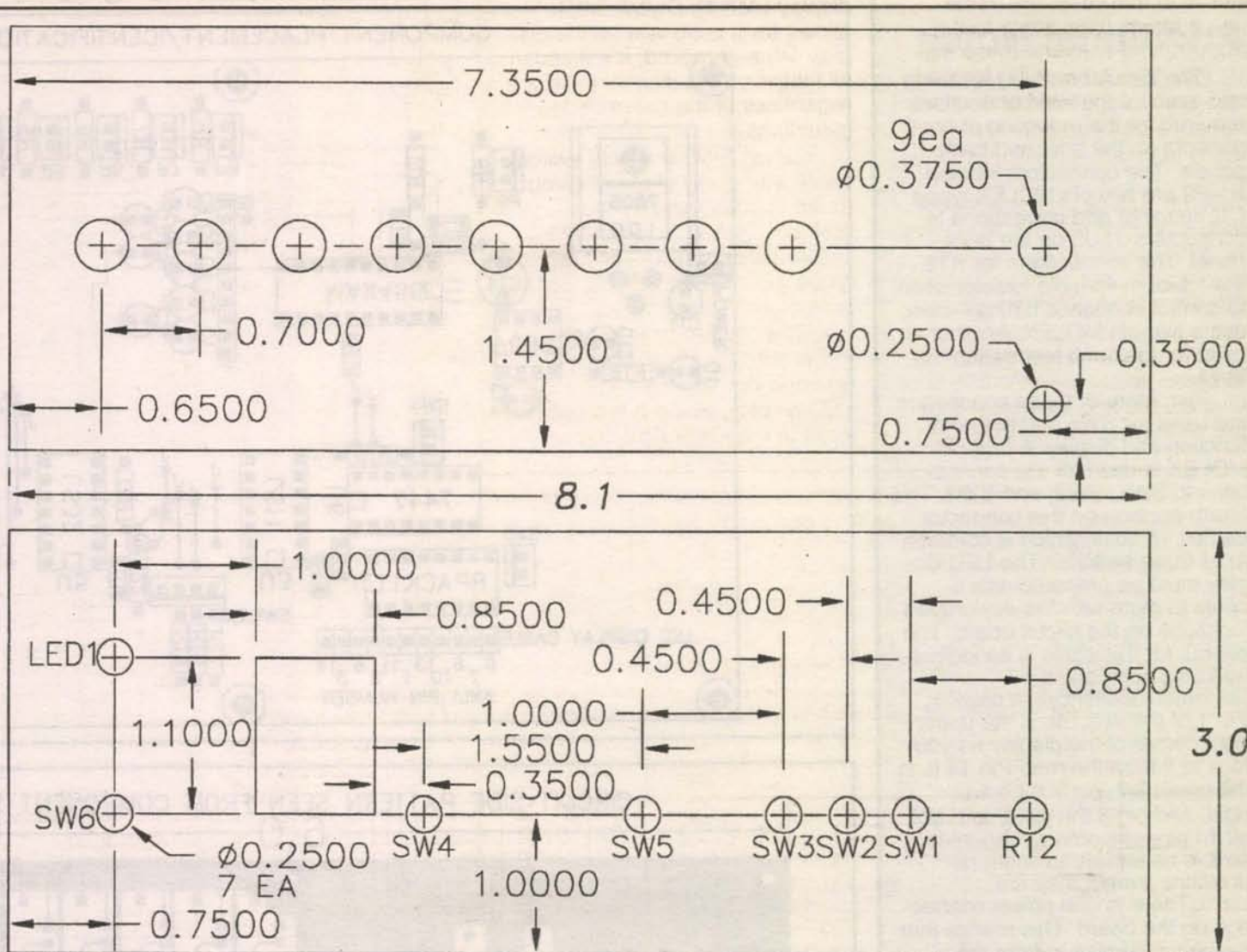


FIGURE 2B  
FRONT AND REAR PANEL HOLE PATTERNS

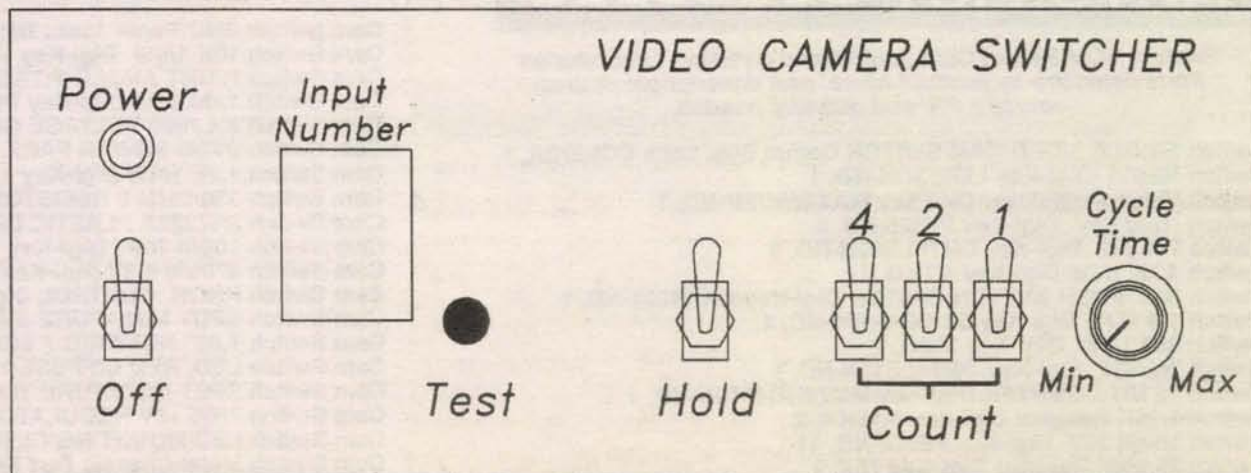
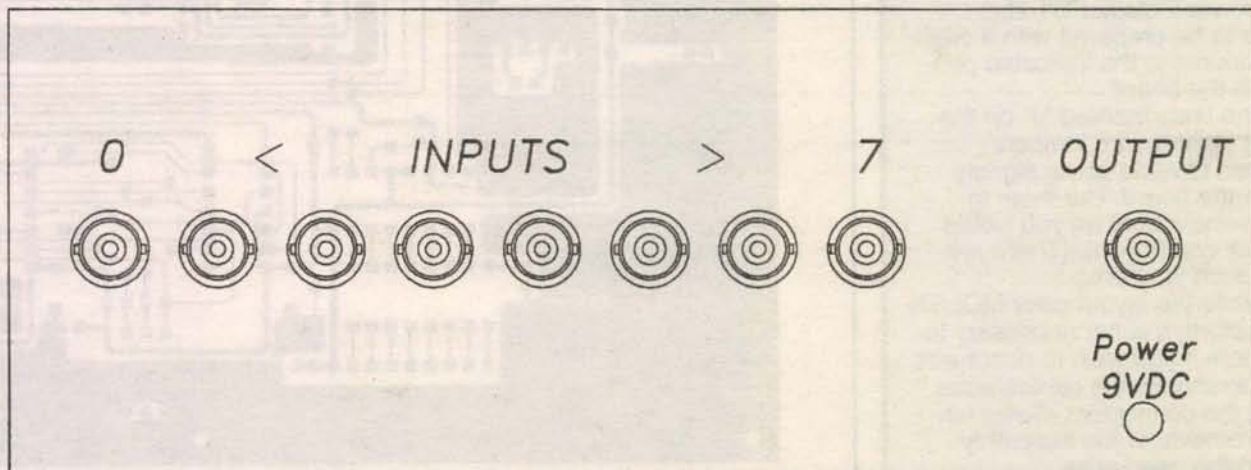
## SWITCH BOUNCE

A word about switch bounce. Switch bounce is the effect that is sometimes seen when switching from one video source to another. This circuit makes no attempt to eliminate bounce, or to blank the output during switching. It simply makes a fast switch from one source to another.

Bounce is caused when two asynchronous video signals are suddenly switched to a monitor. The monitor uses the inherent sync pulses of a video signal to develop the scanned display. If a new video signal with sync pulses that bear no relationship to the one previously being displayed is suddenly substituted to the monitor input, the monitor has to play "catch-up" and find a new vertical sync pulse to trigger the top of the display.

This typically causes at least a half roll of the new display, or video bounce. This effect can be eliminated by using signal sources that are all synchronized to one another. This is a common practice in television studios, where a master sync signal is used for all camera and playback devices.

FIGURE 2A - FRONT AND REAR PANEL LEGENDS





## Additional Notes

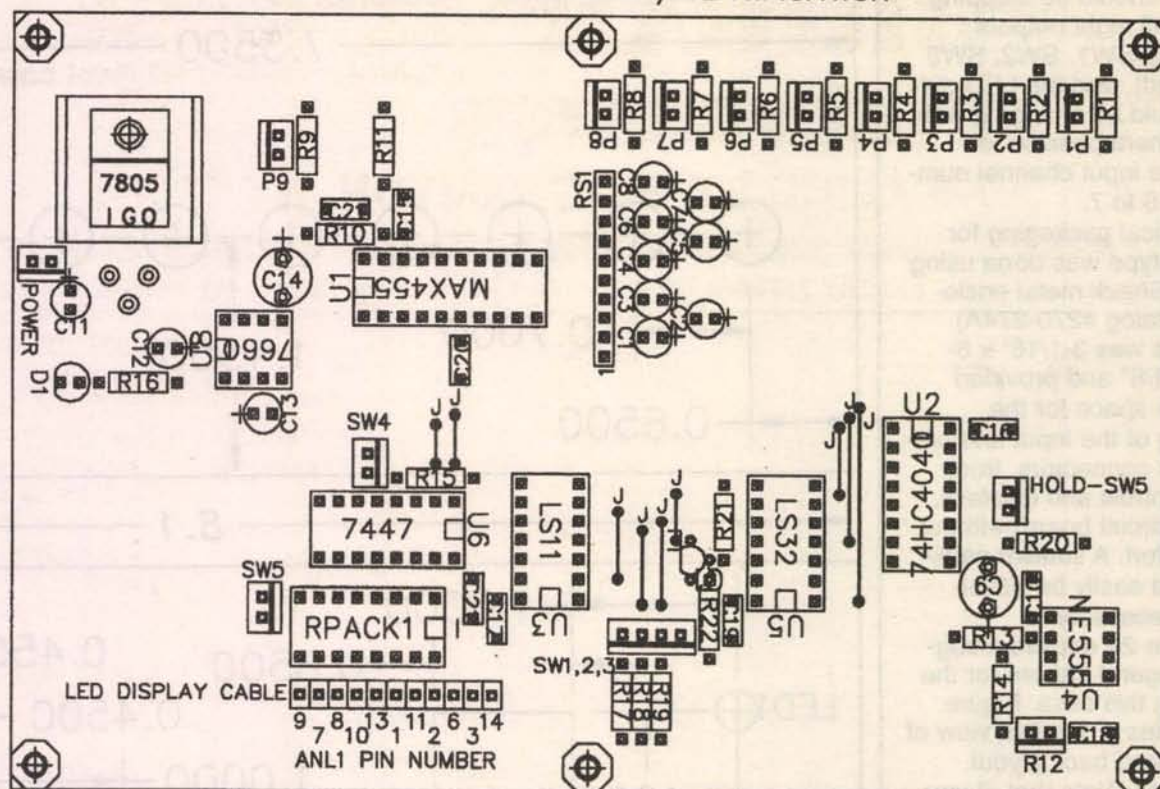
The circuit board layout takes into account the interconnections required for the mounting of components on the front and back panels. The connectors labeled P1-P9 are two pin MOLEX types (.1" spacing) and correspond to connectors J1-J9 on the back panel. The connections for R12 — the 1 Mohm variable resistor used to control sequence timing — also use a two-pin MOLEX. Another is used for the lamp test switch SW4.

Two more of these connectors are used for SW5 and the hold function and display. A four pin MOLEX is used for the connections to SW1, SW2, and SW3. The fourth position on this connector carries +5 volts, which is common to all three switches. The LED display must be prepared with a cable to mate with the designated locations on the circuit board. The pin-out for this cable is as indicated in the component placement/identification drawing. Pin 1 of the ANL1 is in the upper right corner of the display as you look at it from the rear. Pin 14 is in the upper left, pin 7 the lower right, and pin 8 the lower left. Not all 14 pins are actually mounted, so it is necessary to count pin positions even if they are blank. There is one power connection on the board. This means that the circuit coming in from the power jack must be routed to the power switch (SW6) on the front panel, and then back to the power connector on the board. Be sure that the ground connection from the power jack goes directly to ground at the board connector. The power indicator D1 also needs to be prepared with a cable that mounts to the indicated position on the board.

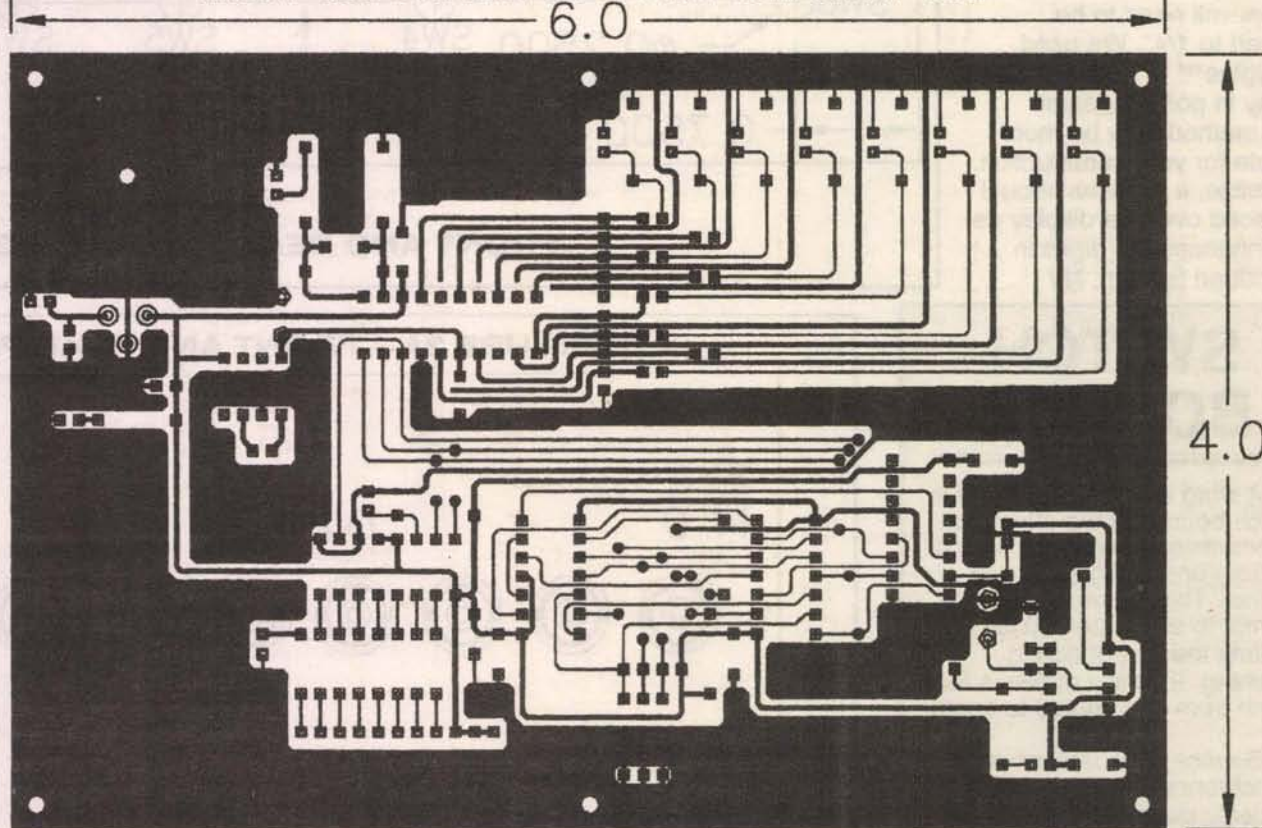
The lines marked "J" on the layout identify wire jumpers required to route some signals above the board. Cut them to length and mount as you would another component. (There are eight such jumpers.)

While the layout uses MOLEX connectors, it is not necessary to use them if you wish to direct wire the interconnecting cables/wires. Using the connectors allows for easy removal of the assembly should the need arise.

## COMPONENT PLACEMENT/IDENTIFICATION



## CIRCUIT SIDE PATTERN SEEN FROM COMPONENT SIDE



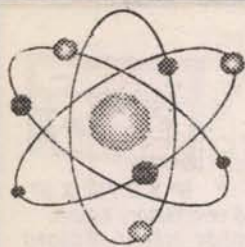
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Product BOM Report Communications Systems Laboratories  
Parts listed are by product name, part description, source,  
source's PN, and quantity needed.

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Cam Switch NE555 Digi-Key LM555CN-ND, 1  
Cam Switch Video Multiplexer Digi-Key MAX455CPP-ND, 1  
Cam Switch .1uF 50V Digi-Key P4525-ND, 8  
Cam Switch 74LS32 Digi-Key DM74LS32N-ND, 1  
Cam Switch 4.7K 1/4W Digi-Key 4.7KQ, 1  
Cam Switch N.O. PUSH BUTTON SWITCH Digi-Key CKN4001-ND, 1  
Cam Switch 1M POT Digi-Key 3310C-1-105-ND, 1  
Cam Switch 330 1/4W Digi-Key 330Q, 1  
Cam Switch 74LS11 Digi-Key DM74LS11N-ND, 1  
Cam Switch 12 BIT COUNTER Digi-Key MM74HC4040N-ND, 1  
Cam Switch 1.15K Resistor Digi-Key 1.15KX, 2  
Cam Switch 10uF 16V Digi-Key P6616-ND, 11  
Cam Switch 75 ohm Resistor Digi-Key 75X, 9

Cam Switch BNC Panel Jacks Digi-Key ARF1064, 9  
Cam Switch 10K 1/4W Digi-Key 10KQ, 1  
Cam Switch RIGHT ANGLE POWER JACK Digi-Key CP-3536-ND, 1  
Cam Switch 1uF 25V Digi-Key P6644-ND, 1  
Cam Switch ICL7660 VOLTAGE CONVERTER Digi-Key ICL7660CPA-ND, 1  
Cam Switch 9VDC POWER PACK Digi-Key T403-ND, 1  
Cam Switch 1.2K 1/4W Digi-Key 1.2KQ, 5  
Cam Switch 330 OHM 8 RESISTOR DIP Digi-Key 4116R-1-331-ND, 1  
Cam Switch 2N2222A PLASTIC Digi-Key PN2222A-ND, 1  
Cam Switch 10pF 100V Digi-Key 1011PHTR-ND, 1  
Cam Switch 470uF 6.3V Digi-Key P6603-ND, 1  
Cam Switch KNOB, CONTROL Digi-Key 10204-ND, 1  
Cam Switch SPDT MINIATURE SWITCH Mouser Corp. 108MS550A, 1  
Cam Switch 1.02" NUMERIC 7 SEGMENT Mouser Corp. 351-1620, 1  
Cam Switch LED, RED DIFFUSED Mouser Corp. 509-EBR5334S, 1  
Cam Switch SPST MINIATURE TOGGLE Mouser Corp. 108-MS550K, 4  
Cam Switch 7805 +5V REGULATOR Mouser Corp. 511-L7805CV, 1  
Cam Switch LED MOUNTING CLIP Mouser Corp. 351-0003, 1  
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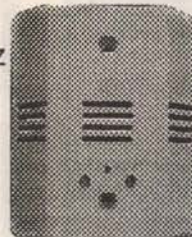
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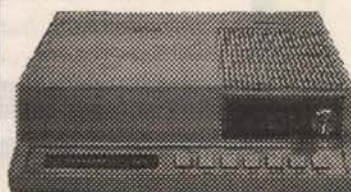
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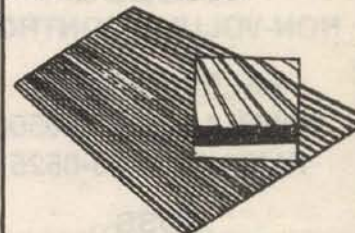
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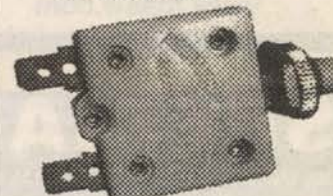
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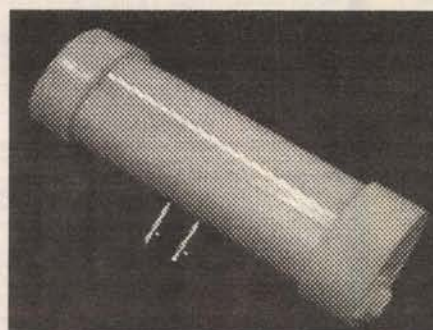
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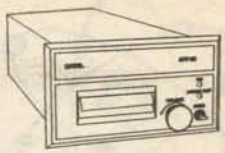
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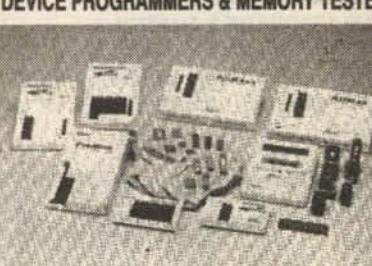
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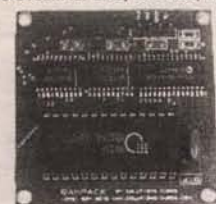


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# Events

## FEBRUARY 1997

### FEBRUARY 1

**CA - FRESNO** - Computer Show & Sale. Fresno Fairgrounds. MarketPro 1-800-708-7555  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052  
**MA - HYANNIS** - Computer Show. Tara Cape Codder Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**TX - AMARILLO** - Hamfest. Potter Cty. ARES. Ben Pollard 806-381-8810

### FEBRUARY 1-2

**FL - MIAMI** - Tropical Hamboree. Dade Radio Club. Youth Fair & Exposition Center. 10901 SW 24th St. Sat. 9am-5pm. Sun. 9am-4pm. 305-642-4139  
**MA - WILMINGTON** - Computer Show. Shriner's. MarketPro 201-825-2229  
**MD - NEW CAROLLTON** - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15  
**MD - PIKESVILLE** - Computer Show. Pikesville Armory. MarketPro 301-984-0880 xt15  
**MO - ST. CHARLES** - Computer Show. St. Charles Exposition Hall. St. Charles Ctr. I-70 & 5th St. Sat. 10am-4pm. Sun. 11am-3pm. Computer Central Shows 888-296-6066  
**MS - JACKSON** - State Convention. Travis Cllett 601-939-9236  
**OH - COLUMBUS** - Computer Show. Ohio Exposition Center. MarketPro 301-984-0880 xt15  
**PA - GREENSBURG** - Computer Show. Greengate Expo Center. MarketPro 301-984-0880 xt15  
**SC - GREENVILLE** - Computer Show. Palmetto Expo Center. MarketPro 201-825-2229  
**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15

### FEBRUARY 2

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857  
**CA - OXNARD** - Computer Show & Sale. Community Center. 10am-5pm. MarketPro 1-800-708-7555  
**CA - STOCKTON** - Computer Show & Sale. Civic Auditorium. 10am-5pm. MarketPro 1-800-708-7555  
**MA - BRAINTREE** - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**MI - GRAND RAPIDS** - Super Computer Sales. Crowne Plaza. 10am-4pm. Computers & You 313-283-1754

### FEBRUARY 7-8-9

**WI - MADISON** - Computer Sale/Show. Dane Co. Expo Center. Blue Star Productions 612-788-1901

### FEBRUARY 8

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**FL - ARCADIA** - Hamfest. Doug Christ 941-494-5070  
**FL - FORT LAUDERDALE** - Computer Show. The Westin Hotel, 400 Corporate Dr. Narissam Computer Shows 770-663-0983  
**FL - MILTON** - Hamfest. Mark McAnally 904-626-7686  
**KS - LACYGNE** - ARRL Hamfest. Mine Creek ARC. Bill VanKirk 913-795-2080  
**MI - LIVONIA** - Super Computer Sales. Elks Lodge

# CALENDAR

The Events Calendar is a free service limited to electronic events such as computer shows, hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days prior to the event. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:

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 Phone 909-371-8497  
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Hall. 10am-3pm. Computers & You 313-283-1754  
**MN - BLAINE** - Midwinter Madness. National Sports Center, Exit #32 off 35 W. N. of Minneapolis/St. Paul. 8am-3pm. RARC 612-537-1722  
**NY - WHITE PLAINS** - Computer Show. Westchester County Center. MarketPro 201-825-2229  
**SC - CHARLESTON** - Hamfest & Computer Show. Stall H.S. in N. Charleston. I-26 & Ashley Phosphate Rd. Northwoods Mall, Waccamaw. Jenny Myers 803-747-2324

### FEBRUARY 8-9

**FL - JACKSONVILLE** - Computer Show. Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15  
**GA - KENNESAW** - Computer Show. I-75 to Exit 116 (Barrett Pkwy) W. 1.5 mi., right on Cobb Pkwy. 1/4 mi., show on right. GA Mountain Productions 706-838-4827  
**MD - NEW CAROLLTON** - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15  
**PA - KING OF PRUSSIA** - Computer Show. Valley Forge Convention Ctr. MarketPro 301-984-0880 xt15  
**TN - NASHVILLE** - Computer Show. Nashville Armory. MarketPro 301-984-0880 xt15  
**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15  
**WV - CHARLESTON** - Computer Show. Convention Center. MarketPro 301-984-0880 xt15

### FEBRUARY 9

**CA - LANCASTER** - Computer Show & Sale. Antelope Valley Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555  
**CA - SANTA ROSA** - Computer Show & Sale. Sonoma Co. Fairgrounds. 10am-5pm. MarketPro 1-800-708-7555  
**FL - WEST PALM BEACH** - Computer Show. Palm Beach Airport Hilton, 150 Australian Ave. Narissam Computer Shows 770-663-0983  
**MI - DEARBORN** - Super Computer Sales. Civic Center. 10am-4pm. Computers & You 313-283-1754  
**NJ - PARSIPPANY** - Computer Show. Parsippamy Hilton. MarketPro 201-825-2229  
**OH - MANSFIELD** - Hamfest & Computer Show. Richland Co. Fgnds. 7am. Pat Ackerman N8YOB. 419-589-7133  
**PA - LATROBE** - Hamfest. Chestnut Ridge ARC. 1811 Ligonier St. 8am-3pm. Bill Demosky

### FEBRUARY 14-15-16

**FL - ORLANDO** - HamCation & Computer Show. Central FL Fgnds., 4603 W. Colonial Dr. St. Rd. 50. Fri. 5pm-9pm, Sat. 9am-5pm, Sun. 9am-3pm. 407-823-7133

### FEBRUARY 15

**CA - BAKERSFIELD** - Computer Show. Kern Co. Fairgrounds. MarketPro 1-800-708-7555  
**CA - VALLEJO** - Computer Show & Sale. Solano Co. Fairgrounds. MarketPro 1-800-708-7555  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052  
**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827  
**MA - MARLBOROUGH** - Hamfest. Ann Weldon 508-481-4988  
**MD - BALTIMORE** - Computer Show. Martin's West. MarketPro 301-984-0880 xt15  
**MI - TAYLOR** - Super Computer Sales. Democratic Club Hall. 10am-3pm. Computers & You 313-283-1754  
**MI - TRAVERSE CITY** - Hamfest. Cherryland ARC. Joe Novk 616-947-8555  
**NH - SEABROOK** - Computer Show. Greyhound Park. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NY - BUFFALO** - Computer Show. Hamburg Fairgrounds. MarketPro 201-825-2229  
**NY - HORSEHEADS** - Hamfest. State Armory, 128 Colonial Dr. Jack Slocum 607-739-4866  
**NY - WESTFIELD** - Radio Amateurs Hamfest & Computerfest. Westfield Academy & Central School. Rt. 20 E. Main St. 8am-3pm. Tom Farnham 716-326-3553  
**OR - RICKREAL** - Salem Hamfair. Polk Co. Fairgrounds. 9am-3pm. James Pardey 503-651-3216  
**PA - OBERLIN** - Winter Hamfest. Oberlin Fire Co. HRAC AnswerLine 717-232-6087  
**TX - SMITHVILLE** - ARRL Hamfest. Bastrop Co. ARC. Charlie Claiborne 512-360-3670  
**VA - ANNANDALE** - Computer Show. Northern VA Comm. College. MarketPro 301-984-0880 xt15

### FEBRUARY 15-16

**GA - NORCROSS** - Computer Show. North Atlanta

Trade Center. MarketPro 301-984-0880 xt15  
**PA - MONROEVILLE** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15  
**VA - ROANOKE** - Computer Show. Civic Center. MarketPro 301-984-0880 xt15

### FEBRUARY 16

**CANADA - BC - WESTMINSTER** - Hamfest. Burnaby ARC. Harry Curtis 604-530-3962  
**CA - SAN DIEGO** - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 1-800-708-7555  
**IL - ROCK ISLAND** - Hamfest. QCCA Expo Center, 2621 4th Ave. Davenport RAC. Kent Williams K9UQL 309-796-0718 4-9pm only  
**IN - NOBLESVILLE** - Computer Fair. Hamilton Co. Fairgrounds, off I-37 exit Pleasant Rd. near Walmart. 10am-3pm. AGI Services 317-299-8827  
**MA - TAUNTON** - Computer Show. Taunton Holiday Inn. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**MD - BOWIE** - Computer Show. Bowie State University. MarketPro 301-984-0880 xt15  
**MI - MADISON HEIGHTS** - Super Computer Sales. UF & CW Hall. 10am-4pm. Computers & You 313-283-1754  
**NC - ELKIN** - Hamfest. Briarpatch ARC & Foothills ARC. Jimmy Holbrook 910-957-3820  
**NY - FREEPORT** - Hamfest. Long Island Mobile ARC. Mark Nadel 516-796-2366  
**NY - ROCHESTER** - Computer Show. The Dome Center. MarketPro 201-825-2229  
**PA - LANCASTER** - Computer Show. Holiday Inn Lancaster Host. MarketPro 301-984-0880 xt15

### FEBRUARY 17

**CA - MODESTO** - Computer Show & Sale. Centre Plaza at Red Lion. MarketPro 1-800-708-7555  
**MA - BOXBOROUGH** - Computer Show. Holiday Inn. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**OH - NILES** - Computer Show. Eastwood Expo Center. MarketPro 301-984-0880 xt15  
**PA - ALLENTOWN** - Computer Show. Allentown Fairgrounds. MarketPro 301-984-0880 xt15  
**NY - SYRACUSE** - Computer Show. The OnCenter. MarketPro 201-825-2229  
**VA - RICHMOND** - Computer Show. The Showplace. MarketPro 301-984-0884 xt15

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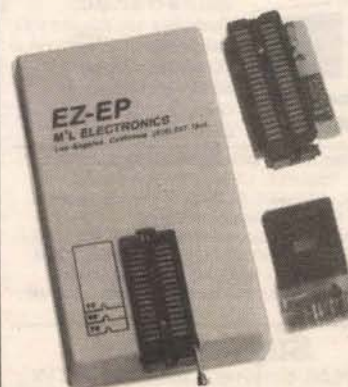
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EP-SOIC28/32	\$49.95	EP-SEE (24xx,93xx Serial EE)	\$34.95
EP-11 (68HC11)	\$59.95	EP-16 (16bit EPROMs)	\$49.95
EP-55 (8755)	\$39.95	EP-49 (8742,48,49)	\$49.95
EP-PLCC32	\$49.95	EP-PEEL (18v8,20g10,22v10)	\$59.95

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# Events CALENDAR

## FEBRUARY 22

**AR - RUSSELLVILLE** - Hamfest. AR River Valley. Dallas Scott 501-967-3317  
**CO - DENVER** - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664  
**CT - STAMFORD** - Computer Show. Stamford Sheraton. MarketPro 201-825-2229  
**FL - SPRING HILL** - Hamfest. Hernando County ARA. Lee Kent 352-799-1638  
**GA - DALTON** - Hamfest. Dalton ARC. Harold Jones 706-673-2291  
**IN - LAPORTE** - Hamfest. LaPorte Civic Center. 8am-2pm. John N9ROH, POB 30, LaPorte, IN 46352  
**MA - WEST SPRINGFIELD** - Computer Show. Eastern States Exposition Ctr. MarketPro 201-825-2229  
**MI - FLINT** - Super Computer Sales. IMA Arena. 10am-3pm. Computers & You 313-283-1754  
**ND - BISMARCK** - CDARC Hamfest. Radisson Inn. 8am-4pm. Tim Rasset 701-663-6620  
**NH - MANCHESTER** - Computer Show. Center of NH Complex. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NJ - TRENTON** - Computer Show. Trenton State. MarketPro 301-984-0880 xt15  
**TX - ORANGE** - Hamfest. Orange ARC. Irene Thomas 409-745-3061  
**VT - MILTON** - Hamfest. Milton High School. Radio Amateurs of Northern Vermont. Mitch Stern 802-879-6589

## FEBRUARY 22-23

**CA - SACRAMENTO** - Computer Show & Sale. Cal Expo. MarketPro 1-800-708-7555  
**CA - VENTURA** - Computer Show & Sale. Ventura Fairgrounds. MarketPro 1-800-708-7555  
**FL - TAMPA** - Computer Show. FL State Fairgrounds. MarketPro 301-984-0880 xt15  
**MD - GAITHERSBURG** - Computer Show. Montgomery County Fairgrounds. MarketPro 301-984-0880 xt15  
**OH - CINCINNATI** - Conv. Great Lakes Division Convention. Cincinnati Gardens Exhibition Center. 2250 Seymour Ave. 8:30am-5pm. Stan Cohen 513-531-1011  
**OH - DAYTON** - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880 xt15  
**TN - KNOXVILLE** - Computer Show. Knoxville Fairgrounds. MarketPro 301-984-0880 xt15

## FEBRUARY 23

**DE - NEWARK** - Computer Show. University of DE. MarketPro 301-984-0880  
**IL - GLEN ELLYN** - Computer Show & Sale. College of DuPage. Main Arena of Phys Ed Bldg. Corner of Park Blvd. & College Rd. Computer Central Shows 847-940-7547  
**MA - WESTFORD** - Hamfest. Greater Boston Antique Radio Collectors. Lisa Friedrichs 508-371-0512  
**ME - PORTLAND** - Computer Show. Verillo's Conv. Center. 10am-3:30pm. Northern Computer Shows. 508-744-8440  
**MI - DEARBORN** - Swap'n Shop. Dearborn Civic Center. 8am-3pm. Neil Coffin 313-261-5486  
**MI - LANSING** - Super Computer Sales. Holiday Inn South Convention Center. 10am-4pm. Computers & You 313-283-1754  
**NY - STONY BROOK** - Computer Show. Suny Stony Brook. MarketPro 201-825-2229  
**OH - CUYAHOGA FALLS** - Hamfest. Emidio's Party Center. 48 Bath Rd. 8am-2pm. Bob Recny N8SQT 330-864-5810  
**PA - PITTSBURGH** - ARRL Hamfest. South Hills ARC. Eric Hegerle 412-341-02270  
**RI - WEST WARWICK** - Computer Show. Civic Center. MarketPro 201-825-2229  
**VA - VIENNA** - Hamfest. Vienna Wireless Society. Jorge Thevenet 703-729-4711

## MARCH 1997

### MARCH 1

**AL - TUSCALOOSA** - Black Warrior Swapfest. Kelly Bruce 205-339-7882  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**GA - ATHENS** - Hamfest. NE Georgia Bubba Net. James Daniel 706-742-2777  
**MD - NEW CARROLLTON** - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15  
**NJ - ABSECON** - Springfest '97 Hamfest. Holy Spirit High School. Shore Points ARC 609-653-1987  
**NJ - PARSIPPANY** - Hamfest. PAL Building. Split Rock/West Morris Radio Clubs. Bernie 201-584-5399  
**OK - ELK CITY** - ARRL Hamfest. West Central OK

ARC. Earl Bottom 405-473-2572  
**TN - CLEVELAND** - Hamfest. Ocoee ARS. Alan Pinney 423-478-1141

### MARCH 1-2

**FL - FT. LAUDERDALE** - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880 xt15  
**GA - COLUMBUS** - Southeastern Computer Show. Historic Iron Works Conv. & Trade Center. Sat: 9am-5pm, Sun: 10am-4pm. Hugh Greenlee 770-455-8997  
**IN - FT. WAYNE** - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15  
**NJ - FAIRFIELD** - Computer Show. Fairfield Radisson. 9:30am-4pm. MarketPro 201-825-2229  
**OH - CINCINNATI** - Computer Fair. Cincinnati Gardens. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378  
**PA - HARRISBURG** - Computer Show. Farm Show Complex. MarketPro 301-984-0880 xt15  
**VA - NORFOLK** - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15

### MARCH 2

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857  
**CT - BRISTOL** - Hamfest. Insurance City Repeater Club. Pete Brunelli 860-620-0176  
**MA - SWANSEA** - Computer Show. Venus DeMilo. 9:30am-2:30pm. Northern Computer Shows 508-744-8440  
**MD - FREDERICK** - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880 xt15  
**PA - TREVOSE** - Photographic Swap/Shop Show. Radisson Hotel. 10am-3pm. OMM Productions 610-527-5903

### MARCH 7-8

**ME - LEWISTON** - State Convention. Dave Blethen 207-353-6433

### MARCH 7-8-9

**LA - LAFAYETTE** - ARRL Hamfest. Acadiana ARA. L. Al Oubre 318-367-3901  
**NE - NORFOLK** - State Convention. Rick Kropf 402-371-7684

### MARCH 8

**CA - FONTANA** - Inland Empire ARC Amateur & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves.  
**FL - ENGLEWOOD** - HamCom '97. Tringali

Community Center, SR 776 Englewood East. 8am-3pm. George Shreve 941-697-3445  
**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827

**KY - HAZARD** - ARRL Hamfest. Kentucky Mountains ARC. 8am-2pm. John Farler 606-436-5354  
**NH - PORTSMOUTH** - Computer Show. Frank Jones Center. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NY - TROY** - Computer Show. Troy Armory. 9:30am-4pm. MarketPro 201-825-2229  
**WA - PUYALLUP** - Electronics Show & Fleamarket. Pavilion Exhibition Hall, Western Washington Fairgrounds. 206-631-3756

### MARCH 8-9

**FL - ORLANDO** - Computer Show. Orlando Expo Center. MarketPro 301-984-0880 xt15  
**GA - KENNESAW** - Computer Show. I-75 to Exit 116 (Barrett Pkwy) W. 1.5 mi., right on Cobb Pkwy. 1/4 mi., show on right. GA Mountain Productions 706-838-4827  
**NC - CHARLOTTE** - Hamfest & Computer Fair. 25 E. Independence Blvd., Hwy 74 E. Sat. 9am-5pm, Sun. 9am-2pm. 704-948-7373  
**PA - KING OF PRUSSIA** - Computer Show. Valley Forge Conv. Ctr. MarketPro 301-984-0880 xt15  
**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15  
**VA - RICHMOND** - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

### MARCH 9

**IN - INDIANAPOLIS** - Hamfest. Morgan Co. Repeater Assn Brian Elliott 317-342-7236  
**IN - INDIANAPOLIS** - Hamfest & Computer Show. State Fairgrounds, East Pavilion Bldg. 317-996-3782  
**ME - AUGUSTA** - Computer Show. Augusta Armory. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NY - LINDENHURST** - ARRL Hamfest. Great South Bay ARC. Walter Wenzel 516-957-0218  
**NY - Poughkeepsie** - Computer Show. Mid-Hudson Civic Center. 9:30am-4pm. MarketPro 201-825-2229  
**OH - CONNEAUT** - Ham/Computerfest. Human Resource Center, 327 Mill St. Jack Marttila 216-593-3353  
**WI - WAUKESHA** - Swapfest & Computer Expo.



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# Events CALENDAR

County Expo Center, N1 W24848 Northview Rd.  
8am-2pm. SEWFARS 414-650-0724

## MARCH 15

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**GA - MARIETTA** - ARRL Hamfest. Kennehoochee ARC. Margaret Durham 770-977-4405  
**MI - MARSHALL** - Hamfest. Marshall High School. 8am-3pm. Wes Chaney 616-979-3433  
**NH - SALEM** - Computer Show. Rockingham Park Race Track. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NY - BUFFALO** - Computer Show. Hamburg Fairgrounds. 9:30am-4pm. MarketPro 201-825-2229  
**TN - KNOXVILLE** - Hamfest. Kerbel Shrine Temple. 8am-4pm. Paul Baird 423-986-9562  
**VA - HARRISONBURG** - Computer Show. Rockingham Co. Fgnds. MarketPro 301-984-0880 xt15

## MARCH 15-16

**FL - TAMPA** - Computer Show. Florida State Fairgrounds. MarketPro 301-984-0880 xt15  
**GA - NORCROSS** - Computer Show. North Atlanta Trade Center. MarketPro 301-984-0880 xt15  
**NY - STONY BROOK** - Computer Show. SUNY Stony Brook. 9:30am-4pm. MarketPro 201-825-2229  
**OK - TULSA** - State Convention/Hamfest. 7th & Houston. Maxwell Convention Center. Merlin Griffin 918-622-2277  
**PA - MONROEVILLE** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15  
**TX - MIDLAND** - ARRL Hamfest. Midland ARC. Beverly Harwood 915-686-1841

## MARCH 16

**IL - STERLING** - Hamfest. Sterling High School Field House. 1608 4th Ave. 815-336-2434  
**MA - WORCESTER** - Computer Show. Crowne Plaza Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**NY - ROCHESTER** - Computer Show. The Dome Center. 9:30am-4pm. MarketPro 201-825-2229  
**OH - MAUMEE** - Hamfest/Computer Fair. Lucas Co. Recreation Center. 2901 Key St. 8am-3pm. TMRA. Paul Hanslik 419-243-3836  
**PA - YORK** - Springfest. Union Fire & Hose Co., E. Canal Rd., Dover, PA. John H. Shaffer 717-764-4805  
**WI - JEFFERSON** - Hamfest. Jefferson Co. Fairgrounds. Tri County ARC 414-563-6502

**WV - CHARLESTON** - Hamfest & Computer Show. Jimmie Hewlett 304-768-1142

## MARCH 21-22-23

**WI - MILWAUKEE** - Computer Show. Milwaukee State Fair. Blue Star Productions 612-788-1901  
**MARCH 22**  
**FL - AVON PARK** - Hamfest & Computer Show. National Guard Armory, 2500 US Hwy 27 South. 8am-2pm. Clyde Scruggs 941-453-7181  
**FL - STUART** - Hamfest. Martin Co. Fairgrounds. Martin County ARA. Romund Madson 561-337-1841  
**IL - BRADLEY** - Computer Show. Ramada Inn, Rte. 50 N. 9am-3pm. Gary 815-935-1605  
**MA - ROCKLAND** - Computer Show. Sons of Italy. 10am-3:30pm. Northern Computer Shows 508-744-8440  
**MO - KANSAS CITY** - Hambash. Ararat Temple. 5100 Ararat Dr. 8am-2pm. Steve Dowdy 816-941-0620  
**NJ - WEST ORANGE** - Hamfest. West Orange H.S. 600 Pleasant Valley Way. 9am-2pm. Jim Howe 201-402-6066

## MARCH 22-23

**FL - JACKSONVILLE** - Computer Show. Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15  
**IN - INDIANAPOLIS** - Computer Show. Indiana State Fairgrounds. MarketPro 301-984-0880 xt15  
**IN - NASHVILLE** - Computer Show. Nashville Armory. MarketPro 301-984-0880 xt15  
**NC - CHARLOTTE** - Computer Show. The Merchandise Mart. 9:30am-4pm. MarketPro 201-825-2229  
**NY - WHITE PLAINS** - Computer Show. Westchester Co. Center. 9:30am-4pm. MarketPro 201-825-2229

## MARCH 23

**CA - SANTA ANA** - Swapmeet. ACP parking lot. Mary Russo 714-558-8813  
**IL - GLEN ELLYN** - Computer Show & Sale. Harper College. 9:30am-3pm. Computer Central Shows 847-940-7547  
**IL - GRAYSLAKE** - LAMARSFEST '97. Lake County, IL Fairgrounds. 8am-2pm. Frank Avellone 847-234-4124  
**NC - KINSTON** - ARRL Hamfest. Dwon East Hamfest Assn. Dough Burt 919-524-5724  
**NH - NASHUA** - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows

508-744-8440

**NJ - TRENTON** - ARRL Hamfest. Delaware Valley Radio Assn. Darryl Foyuth 609-882-2240  
**NY - YONKERS** - ARRL Hamfest. Westchester Emergency Communications Assn. Thomas Raffaeli 914-741-6606  
**OH - MADISON** - ARRL Hamfest. Lake County ARA. Roxanne 216-256-0320  
**PA - WILKES BARRE** - Computer Show. Genetti's Best Western. MarketPro 301-984-0880 xt15  
**VA - ROANOKE** - Computer Show. Civic Center. MarketPro 301-984-0880 xt15

## MARCH 28-29

**GA - COLUMBUS** - ARRL Hamfest. Columbus ARC. Randy Hancock 706-596-8820

## MARCH 28-29-30

**GA - AUGUSTA** - Garden City Channel Masters CB Club 15th Annual Break. Radisson Hotel & Conference Center. Moses 706-793-7828

## MARCH 29

**CO - DENVER** - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664  
**IN - MICHIGAN CITY** - Hamfest & Computer Fleamarket. Michigan City High School, 8466 W. Pals Rd. 8am-2pm. Ron Stahovick 219-325-9089  
**MD - GAITHERSBURG** - Computer Show. Montgomery Co. Fgnds. MarketPro 301-984-0880 xt15  
**OH - COLUMBUS** - Computer Show. Veterans Memorial. MarketPro 301-984-0880 xt15  
**PA - HARRISBURG** - Computer Show. Farm Show Complex (East Bldg). MarketPro 301-984-0880 xt15  
**TX - WEATHERFORD** - Hamfest. ARC of Parker County. Allen Griffith 817-441-9114

## APRIL 1997

### APRIL 5

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**CO - LONGMONT** - Hamfest. Longmont ARC. Jim Deeming 303-651-7764  
**CT - WATERFORD** - Ham Radio Auction. Waterford Senior Center. Rte. 85. Tony 860-859-0162  
**FL - MIAMI** - Tailgate Swap Meet. Parking lot Univ. of Miami, main campus. 8am-noon. Walt 305-895-

0398

**IN - COLUMBUS** - Hamfest. Bartholomew Co. 4-H Fairgrounds, Community Bldg. 8am-2pm. Marion Winterberg 812-342-4670  
**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827  
**MA - WEST SPRINGFIELD** - Computer Show. Eastern States Exposition. 9:30am-4pm. MarketPro 201-825-2229  
**OK - LAWTON** - ARRL Hamfest. Lawton Ft. Sill ARC. Bob Morford 405-353-8074

## APRIL 5-6

**MD - TIMONIUM** - ARRL State Convention/Amateur, Computer and Electronic Flea Market, Show & Sale. Timonium Fairgrounds. Sat: 8am-5pm, Sun: 8am-4pm. 410-HAM-FEST

## APRIL 6

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Ankam 510-447-3857  
**NY - Poughkeepsie** - Computer Show. Mid-Hudson Civic Center. 9:30am-4pm. MarketPro 201-825-2229  
**RI - WEST WARWICK** - Computer Show. Civic Center. 9:30am-4pm. MarketPro 201-825-2229

## APRIL 11-12

**MS - TUPELO** - ARRL Hamfest. Jack Ellis 601-842-7255

## APRIL 12

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves  
**KY - BOWLING GREEN** - ARRL Hamfest. Leon Garrett 502-842-5307  
**MN - ROCHESTER** - ARRL Hamfest. Rochester ARC. John Scott 507-732-5091  
**NY - BUFFALO** - Computer Show. Hamburg Fairgrounds. 9:30am-4pm. MarketPro 201-825-2229  
**PA - FREDERICKSBURG** - ARRL Hamfest. Mark Schropp 717-754-7700  
**UT - OGDEN** - State Convention. Kathy Rudnicki 801-547-9218

## APRIL 12-13

**GA - ATLANTA** - Ham & Computer Festival. Tim Vogle 770-593-3962  
**GA - KENNESAW** - Computer Show. I-75 to Exit  
Continued on page 114

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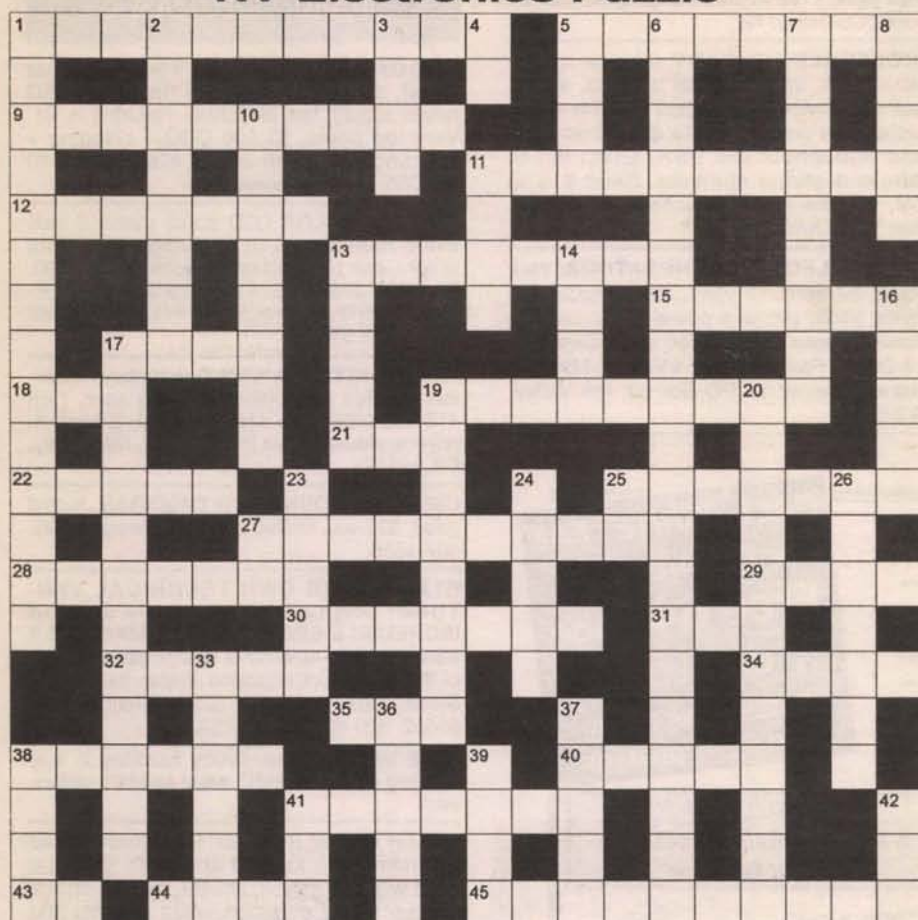
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# NV Electronics Puzzle



## ACROSS

1. A receiver that is synchronized is this
5. A mobile charge carrier
9. A summing circuit
11. Contemporary condensers
12. The expected value
13. A current opposing component
15. A circuit that cannot support a current
17. This means 10
18. Old name for the IEEE
19. General name for opposition to current
21. Component of solder
22. Electronics' one-way street
25. Radios and butterflies both have them
27. Old-timers transistor
28. It isn't hot or cold
29. MOS transistors
30. Why charges move
31. Acronym for a type of symbol interference
32. Common to diodes, batteries, and tubes
34. An op-amp figure of merit
35. A capacitor figure of merit
38. A transient troublemaker
40. Del by another name
41. The unit of charge goes to him
43. A circuit whose current changes direction
44. The average value
45. The first solid-state amplifier

## DOWN

1. One end of a transformer
2. Tells how fast an op-amp's output can change
3. An interface device for your fingers
4. A circuit whose current does not change direction
5. A commonly used antenna equivalency spec
6. Radio and light, but not water or sound
7. It can create music and destroy bridges
8. Any unwanted signal
10. All good DC power supplies do this
11. Colloquial name for an integrated circuit
13. After power-up, you should do this to your CPU
14. The reciprocal of frequency
16. A type of three-phase circuit
17. What a receiver does best
19. An energy storage device
20. Part of a polynomial
23. Old name for a rectifier
24. A subcircuit in series with others that "act" together
25. A class of amplifiers
26. The frequency of oscillation when there is no damping
33. Pet name for a common piece of test equipment
36. Something in parallel
37. This animal is used with LCD displays
38. Carl Sagan would like this prefix
39. The place where ships and cables come in
41. If an IC isn't a DIP, it may be found in this
42. It's definitely not an OR gate

Solution on page 85

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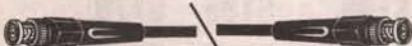
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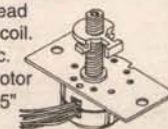
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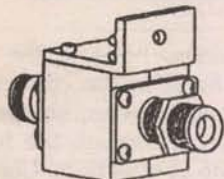
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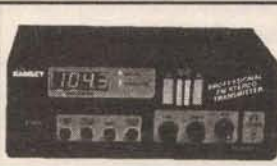
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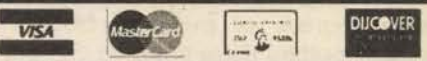
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by Karl Lunt

# AMATEUR ROBOTICS

## Build the Marble Maze-Runner

**N**ot all robots need wheels, nor do they have to run around on the floor. This month's machine rolls a marble through a tabletop cardboard maze, and can serve as the starting point for kinetic sculpture or other robotic art.

The MENSEA organization asked some of us from the Seattle Robotics Society to give an informal talk on hobby robotics. This seemed like a good reason to build another 'bot, so I started sketching ideas for my newest creation. Rather than build another wheeled platform, I set out to design a tabletop unit that could do "something cool." Gradually, the disorganized wishlist sorted itself out, and I determined to build a robotic platform that could tilt a platform in two degrees of freedom, so as to move a marble through a small maze.

Having decided on the problem I wanted to solve, I then began sketching out possible solutions. I figured I could build this easily, using a 68hc11 BOTBoard and a couple of unmodified Futaba S-148 hobby R/C servos. Longtime readers of this column are no doubt familiar with how I hook these components together, and past columns are filled with info on using them.

My first attempt at the maze robot involved a platform resting on four 2" legs, each leg fastened to one corner of the platform. Each leg would be hooked to a clevis, in turn, hooked to the control horn of a servo motor. In theory, each servo motor could then raise or lower its corner of the platform. With coordinated movements of two servos, I could then tilt the platform in any direction.

Unfortunately, this scheme proved unworkable for me. I did not have the necessary in-line ball joint needed to mount each leg onto a corner of the platform. Unless these joints can pivot through 360 degrees, the table isn't free to tilt. And while such items undoubtedly exist, I couldn't find anything suitable in my price range.

So I took the easier course and re-thought my design. This time, I came up with a pair of servo motors, fastened together to form a powered joint with two degrees of freedom. The body of the upper servo is firmly fastened to the control horn of the lower motor. This lets the lower servo swing its partner from side to side. I then fastened a shelf, made of thin Sintra shaped into an L-bracket, to the upper servo's control horn. This arrangement lets me roll and pitch the shelf in any direction. See the accompanying diagrams.

As you can see, the mechanism is quite simple, and can be extended by adding extra servos for more degrees of freedom. Note, however, that actually putting these together can get a little tricky. First of all, hook each servo you intend to use to some type of test rig, such as a BOTBoard with suitable software, and verify that the motor actually works. Also verify that the motor will give you at

least 90 degrees of motion. Most will, but sometimes a clunker sneaks through QA, and you're better off finding it now. Once you bolt this rig together, you won't want to take it apart again!

Next, fashion the L-bracket shelf from some light, sturdy material. I found some 1/8" Sintra scrap at the local plastics store, already formed in the necessary right angle; a piece eight inches long worked for me. You could also use very light aluminum or ABS. Note that you must leave clearance between the underside of the shelf and the top of the upper servo when the assembly is put together. Therefore, you will need a flange at least 2" wide where you can attach the servo's control horn.

Cut this L-bracket material as shown, then drill

care to align the three screw holes in the shelf's flange with the selected holes in the control horn. Run three small sheet metal screws, shipped with the servo hardware package, through the holes in the shelf flange and into the control horn. Use heavy nippers or horseshoe nail clippers to cut off the protruding ends of the screws.

Temporarily fit the shelf and control horn to a servo to verify alignment. You should be able to move the shelf through at least 90 degrees without hitting any part of the servo's case. If the mounting ears on the servo case interfere, just cut them off with heavy wire cutters, then sand or file the case smooth. After you are satisfied with the alignment, heat up the hot glue gun and run a bead of glue

around the perimeter of the control horn to solidly fasten it to the shelf flange.

Next up, you need to fasten the upper servo to the control horn for the lower servo. In this case, you must first bolt the control horn to the lower servo before proceeding. Put a couple of strips of foam tape on the control horn surface, then lightly press the upper servo to the tape to check alignment. With the shelf fastened to the upper servo, you should be able to roll and pitch the shelf flange through 360 degrees without interference. If necessary, you can also cut the mounting

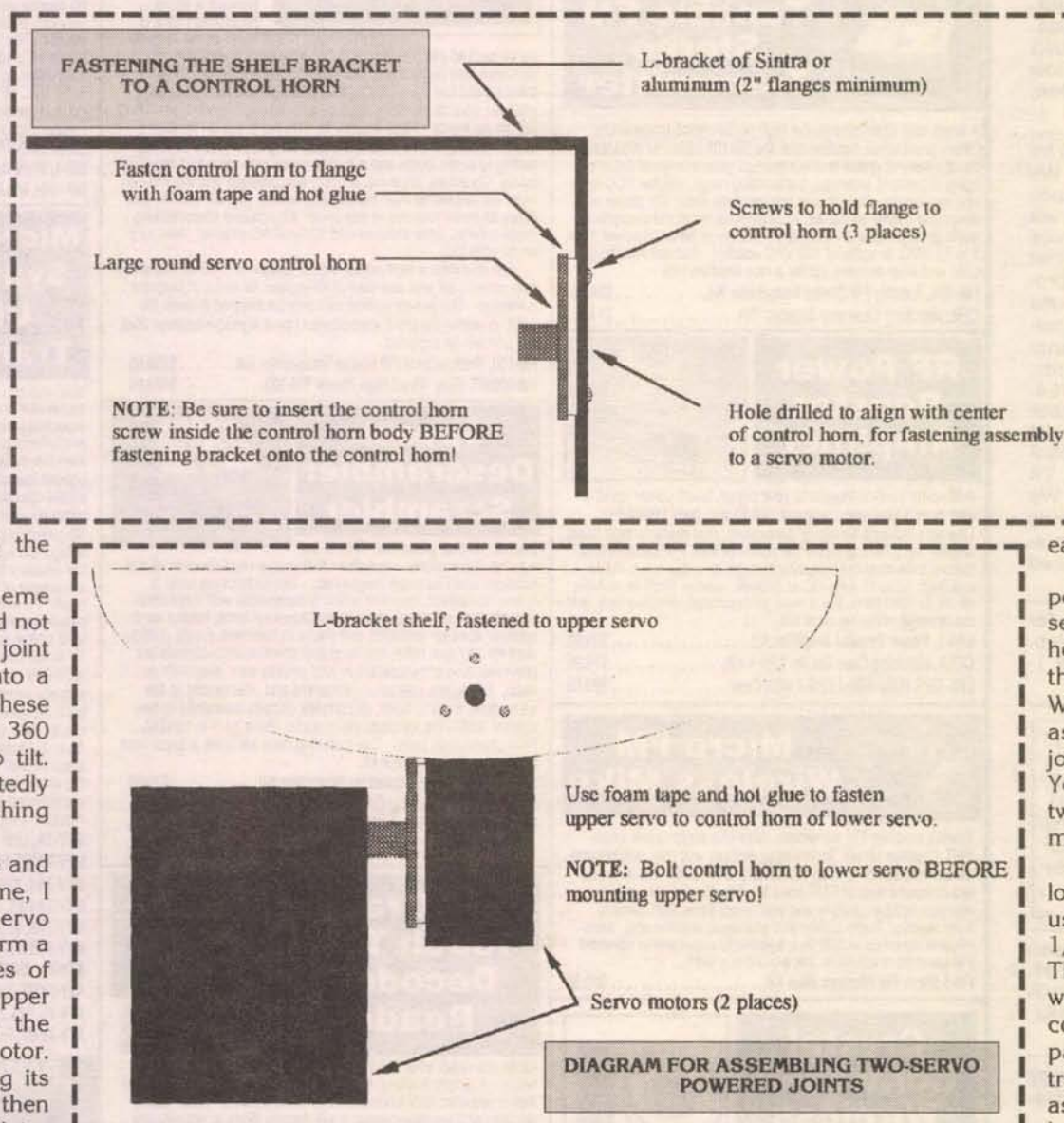
ears off of the lower servo.

When you are satisfied with the performance, firmly press the upper servo into place, then run a bead of hot glue around the perimeter of the lower servo's control horn. When cool, this glue will bond the assembly into a single powered joint with two degrees of freedom. You should be able to hook these two servos to a BOTBoard and move the platform as needed.

Next up, you have to mount the lower servo to some type of base. I used a base made from a sheet of 1/4" white Sintra, cut to 11" by 11". The dimensions were intentional; I wanted the whole unit to sit comfortably in an empty Xerox paper box, making it easy to transport. I placed the two-servo assembly on the base so the L-bracket's pivot point sat at the

base's center. I then marked two dots on the base, one on either side of the lower servo at the center of the longer side. After drilling two 1/8" holes at these dots, I used foam tape to stick the lower servo in place, ran a nylon wire tie through the holes, and cinched it down to clamp the motor. A bead of hot glue around the servo at the base finished the mounting.

With the mechanical mounting complete, I was able to grasp the upper shelf of the L-bracket and slowly move the bracket right, left, forward, and backward from stop to stop on both servos. Be sure



a 1/8" hole where you will put the center of the servo's control horn. Next, take a spare control horn and align its center hole with the hole you just drilled. Select three evenly-spaced holes on the perimeter of the control horn and mark through these holes onto the L-bracket material. Drill these marked holes, using a 3/16" drill bit.

Now you should be ready to mount the shelf to the control horn. Note you must FIRST insert the control horn's mounting screw into the bore of the horn! With the screw in place, use double-sided foam tape to stick the control horn to the shelf. Take



that all mechanical connections are firm and solid, since any slop will cause the maze platform to wobble during use. Note that some slop is inherent, due to the design of the servo motors. You can expect a few degrees of play around both servo shafts. But do what you can to make all the other mechanical connections solid.

Next up, I added the electronics. This consisted of a 68hc11 BOTBoard loaded with a 68hc811e2 microcontroller (MCU) and two battery packs. The larger pack holds four C-cells, used to provide power for the two servo motors. The four AA-cells in the smaller pack run the MCU.

You almost have to use two supplies for this machine, since the servos will draw so much current as they change position that the voltage will sag below the MCU's reset threshold, resetting the processor.

Mounting the electronics took nothing more than some foam tape on the underside of the battery packs and a dab of hot glue at each corner of the BOTBoard. I also wired two SPST switches, one in series with each battery pack, so I could control the voltage from either pack individually. This came in very handy when I was testing the software, since I didn't want the maze whipping back and forth during my trials.

Everything mechanical was done now except the fun part; designing a maze to run a marble through. I started by cutting a piece of 1/4" gator board to a 10" by 10" square. Gator board is a tough, plastic-coated version of foam-core, sometimes available at art and industrial art stores. You could probably substitute heavy corrugated cardboard as well. I decided against Sintra for weight reasons; I wanted to keep the mass at the end of the servo's arm as small as possible.

I then doodled around on a piece of quadrille paper, trying different maze arrangements. I only used segment lengths that were multiples of 1", to make the final construction as easy as possible. After a few trials, I came up with the maze layout shown here. When I was satisfied with the layout, it was time to build it up.

Since the gator board had a white surface, I hunted up some white 1/16" cardboard, similar to shirt cardboard. Using an X-acto knife, I cut out many 1" wide strips of this cardboard. I then cut these into an assortment of shorter strips, in 1", 2", 3", and 4" lengths. I also cut a few 5" and 6" lengths, as well.

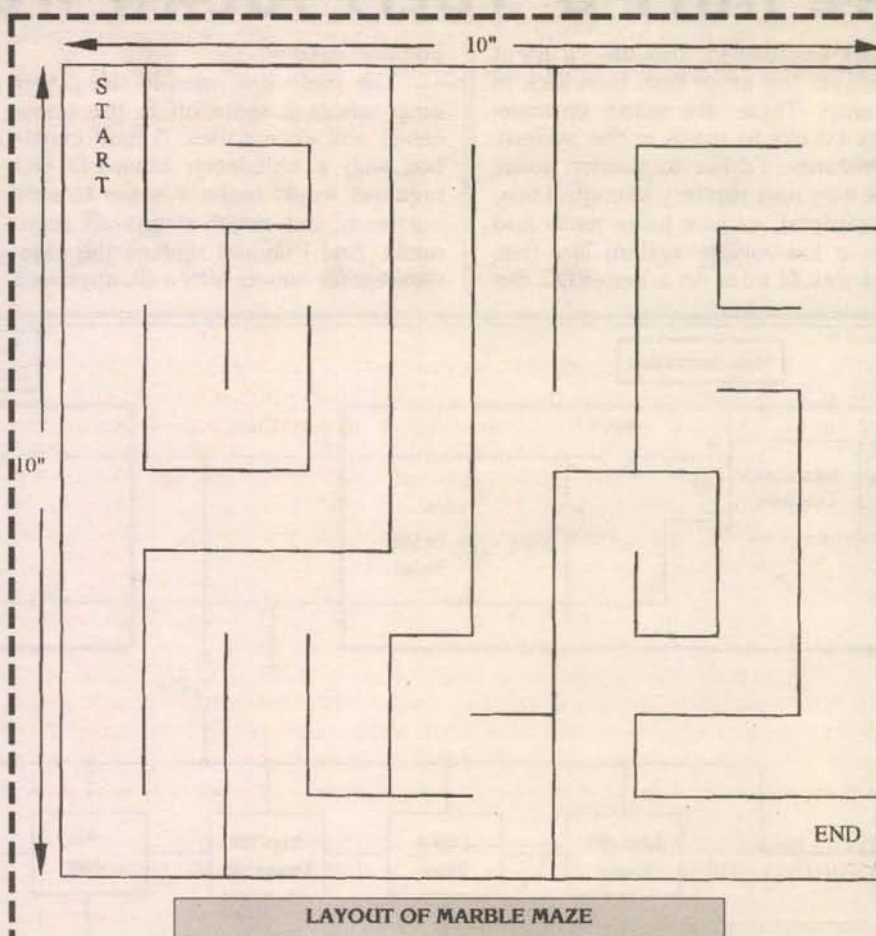
I began the maze construction by building a 1"-high wall completely around the outside of the maze base. I held this in place with masking tape on the lower outside edge and a bead of hot glue on the lower inside edge. I also used hot glue on the four inner corners.

Working from my layout page, I then started at one corner of the maze base and carefully placed each maze wall. A quick dab of hot glue at the seam between wall and floor held the wall in place.

Since every wall touches at least one other wall at a right angle, I ran a bead of hot glue along that vertical edge, providing more support. After the glue cooled, I was ready to fasten my maze to the top shelf on the L-bracket. Just a couple of pieces of foam tape and the project was nearly complete; I only needed a little bit of software.

### The maze software

I envisioned this project as an interactive design, one in which a user could try to guide the marble through the maze. I also wanted the robot to



be able to run the marble itself, to show how easy the task is. Finally, the software had to support a means of leveling the platform. I could have tried shimmying the base every time I set up the maze, but that's kind of lame. Using the software to adjust the resting position offered a more elegant solution.

All of the above features require some type of control for the human to use, and I had a lot of options available. I could have used some slide switches to select what mode to use (adjust, robot play, or human play), two knob knobs for tweaking the maze's pitch and roll during leveling, and a joystick for actually controlling the maze.

But a little luck came my way at exactly this point in the design. VETCO, a local surplus store, set out a box of small, single-board RS-232 terminals. Each handheld terminal sported a two-line-by-24-character LCD display, and a 12-key keypad that included all 10 digits, an Enter key, and (oddly enough) a blue wheelchair symbol. The price was right, at under \$20.00, so I snapped one up.

When I got it home, I removed the backlighting, which really sucked the juice, and I shorted out the voltage regulator. This left me with a terminal that only needed +5 VDC to run. I then wired a four-conductor cable so I could hook the terminal to my BOTBoard. I tapped into the receive and transmit signals on the MCU side of the terminal's RS-232 level shifter, so both signals were logic-level as needed by the BOTBoard.

This terminal added some real capabilities. Now I could have the robot software report its pitch and roll settings, so I could trim the maze quickly. I could even build in some simple menuing, allowing me to switch between the three different modes with a single keypress.

The final software breaks down into three major components, with the active component selected by the operator through a menu system. The first element, dubbed GAME, lets the operator control the position of the platform using the major nine keys on the keypad. Thus, the five-key centers the maze, while the two-key pitches the maze platform forward, and the nine-key simultaneously pitches it backward and rolls it right.

The second element, which I call PLAY, causes the robot to execute a fixed series of pitches and rolls, moving the marble on a preset

course through the maze. This sequence assumes that the marble is already in the starting position at the upper-left corner of the maze. Since the robot has no sensors for feedback, this element is a simple open-loop set of commands.

Finally, the third element (ADJ) lets me adjust the initial position of the maze platform, using the main nine keys as described in GAME above. Each press of one of the eight outer keys tilts the maze slightly in that direction; pressing the five-key returns the maze to the currently defined center position, so I can start over if I choose. Once I have the maze centered, I can press the zero-key to lock in the position as the new center position. This adjustment is written to RAM and stays in place so long as the MCU has power.

I began the software by building the ADJ element, so I could determine the servo values to use to center the maze on my work table. These two servo values became the starting position following power-up. With ADJ running, I then added the menuing system so I could toggle between ADJ and GAME, which was the next step.

The GAME element let me actually try running the marble myself, and I spent about half an hour in "research." Though the maze is pretty simple on paper, getting the timing and motions down

proved quite a challenge.

Using the GAME element, I mapped out the series of moves needed to run the marble from its starting position to the end. The move sequence involved time duration, as well as pitch and roll instructions. For each move, the robot had to tilt the platform, then wait long enough for the marble to respond. It only took a few minutes to build up a table of tilt instructions and durations, using the keypad to provide steering. These instructions formed the core to the final element, PLAY.

Next, I converted my list of moves into a data table and added a subroutine that would step through the table, first doing the required tilt motion, then waiting the prescribed delay. When the code was finished, I could use the keypad to select PLAY, then watch my robot move the marble completely through the maze on its own.

Needless to say, this robot was a hit at the Mensa gathering, and the guys at the Seattle Robotics Society got a kick out of it as well. Randy Sargent, one of the Newton Labs team that has been making such a splash in the world-wide robotics contests recently, got all excited about hanging a camera over the maze, then having a robot run the maze on its own, without a table of instructions. Sounds really cool, and I'll keep you posted if the team finishes the project.

For now, I've got a cool show-bot that is both interactive and entertaining. You can put one together in a weekend or so, using little more than a BOTBoard, a couple of servos, cardboard, and hot glue. I'll move the code to my web site so you can build from it. You won't have the small terminal like I did, but you could hook the maze robot to your PC and use the PC's keyboard instead. Or you could rewrite the software to use switches and joysticks. Regardless of your approach, I'm sure you'll have a blast with this machine. **NV**

**As always, you can reach me at:**

**Karl Lunt**

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Bothell, WA 98012

**E-Mail:** karl@mav.com

**Web:** <http://www.seanet.com/~karllunt>



# THE NUTS & VOLTS SOLAR WORKSHOP

bench, I often just let the receiver give me some band chatter as I work. In general, I spend about two to three hours listening, with much less talking. It's hard to figure out how much talking I do, perhaps five percent on a busy afternoon. I usually have the linear amplifier on.

If the signal is very strong and the

airways uncrowded, though, I'll try it "barefoot" (no amp) first, then kick in the amp. There are some improvements I'd like to make to the system. For instance, I'd like to shorten some of the wire runs (battery to control box, for example), as wire losses really add up in a low-voltage system like this. And I should work on a better DC dis-

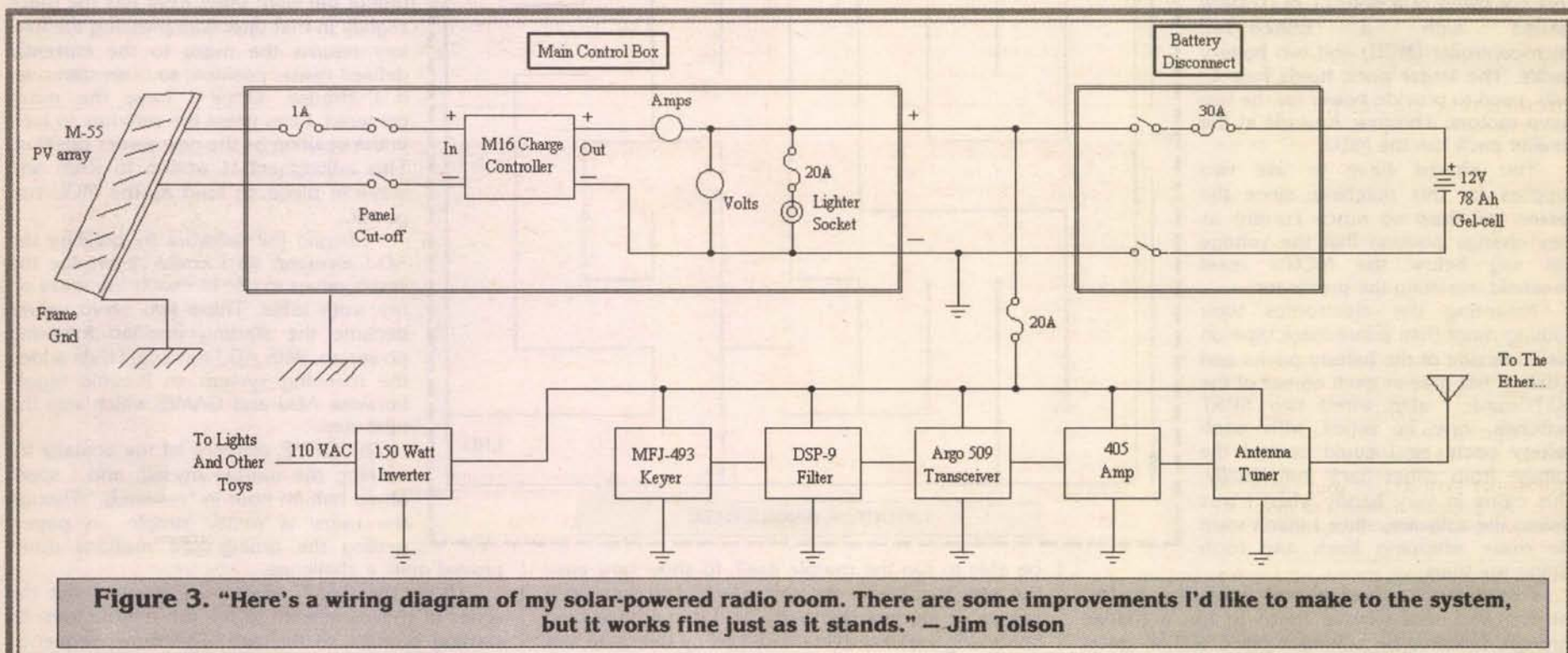
tribution method.

The main run goes to the power amp, where it splits off to the transceiver and accessories. A load center box with a half-dozen Square-D QO breakers would make it easier to split out feeds and switch things off separately. And I should replace the cigarette lighter outlets with a UL-approved

connector of some kind.

Still, the set-up has worked fine for over a year, despite the fact that it took me two decades to get plugged into the sun! I hope it doesn't take you as long to get up to speed. When you do, I know you'll find it as big a kick as making that Asian contact.

Take care, and goodnight. **NV**



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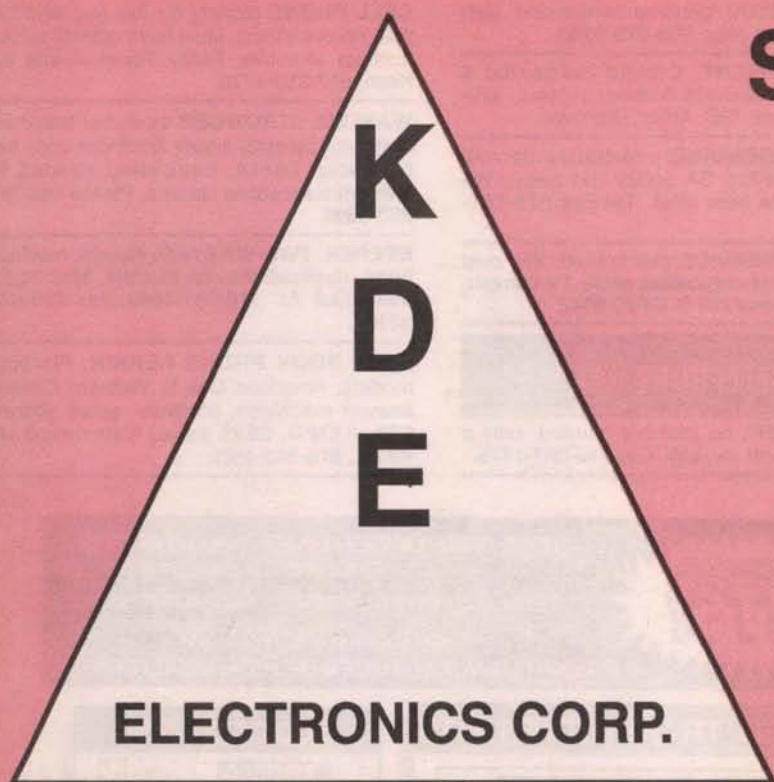
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VGA Monitor, 5 pin Keyboard & DB9 Serial Port  
VGA Monitor, 5 pin Keyboard & DB9 Serial Port

#### Switch Type

A/B

A/B

A/B/C/D

A/B

A/B/C/D

A/B

A/B/C/D

A/B

A/B

#### Part#

#DS-HD2

#DS-5DIN-2

#DS-5DIN-4

#DS-HD2-5

#DS-HD4-5

#DS-HD2-6

#DS-HD4-6

#DS-HD2-59

#DS-HD4-59

#### Each

\$11.00

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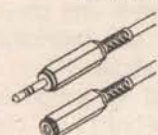
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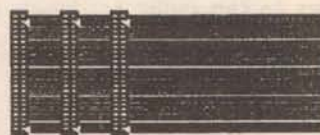
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\$1.00 each

50 & up .75¢

### SCSI Cable

36" 50 pin 2 device



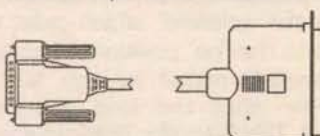
#CC-344

\$3.00 each

20/\$2.60 each 50/\$2.30

### SCSI Cable

IBM or MAC Controller to device  
DB25 to 50 pin Centronics male to male



#CC-669

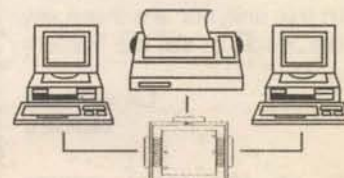
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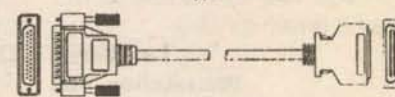
All DB25 female connections



#DS-201P \$8.00 each

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10' Bi-Directional  
DB25 Male to Mini Centronic 36  
A.K.A type "A" - "C"



#CC-PR6-BIMIN

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Any Quantity

Blow Out!

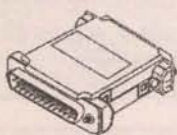
### Centronics Adaptors

DB25 male to 36 pin female Centronics

#CA-180

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Close Out!



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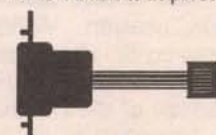
#TM-MIC-3

\$4.00 each

3/\$10.00

### Parallel Port

DB25 Female to 26 pin socket IDC

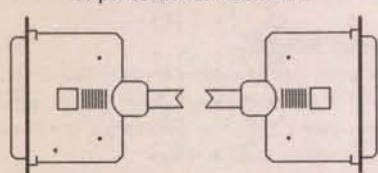


#CN-702 \$.50 each

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### SCSI 1 to SCSI 1 Cable

50 pin Centronics male to male



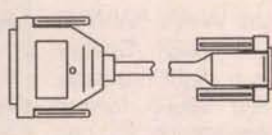
#CC-676-E

6 foot \$2.00 each

Close Out!

### AT Modem Cable

DB25 male to DB9 Female



Close out

9 foot #CC-906 \$1.50 each

20/\$1.00 each

### 10' Bi-Directional Printer cable

DB25 male to standard 36 centronics

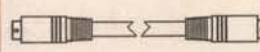


Cable for HP Laser  
and others meets  
1284-IEEE standards

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4ft cable  
Oxygen-Free wire  
4 pin mini  
male to male



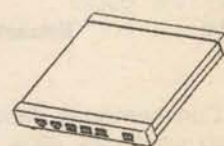
#VC-735-4

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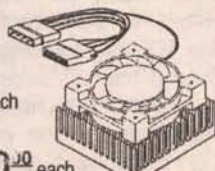
Sleeve Bearing

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Ball Bearing

#TM-FAN-90BB Pentium CPU, 75-150 MHz \$10.00 each



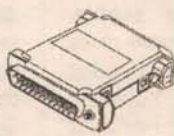
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# Questions & Answers

# TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

## QUESTIONS

At a local flea market I picked up a Simpson 260, series 5P multimeter. I need to know what type of batteries power this unit. There is no owner's manual with this unit, nor are there any labels on the inside to tell the battery types used.

**2971** **Leroy Heck**  
**N8UEV**

I have an HP Laser printer #2686A and it just has a serials looking port, there is no parallel port and it won't work on the parallel port on my PC. It was used in an large office environment. Could some one have information on this and forward it to me. Also I need a driver for this.

**2972** **Len Vereb**  
**Wenatchee, WA**  
**jlvreb@juno.com**

Since I no longer subscribe to a Caller ID service, but still have the display box, I was wondering if it could be converted into a TouchGrabber/DTMF Touch Tone Reader that could be used in conjunction with a scanner. (Without too much trouble hopefully.) Does anyone have information, solutions, or schematics in this area?

Also, I was wondering how I might locate the detector in an FM receiver so an SCA detector could be installed.

**2973** **Jerry Leonard**  
**Edwardsville, IL**

How much laser power is required to cut soft woods such as balsa/bass wood 1/4" thick?

**2974** **Stuart B. Wahlberg**  
**Blythe, CA**

Can someone describe a power supply which will allow common telephones to be used as intercoms using two-wire cable? Power for both the speaking circuit and the ringer is needed.

**2975** **Tom Weikel**  
**Goldenrod, FL**

We would like to record temperature of water in a flooded mine shaft at Hurley, WI. It is vertical +3,600 feet deep. The water temperature ranges from 52°F at top to 80°F at bottom. We need a reasonably priced device to check the temperature every 100 feet. Can someone out there design one for us?

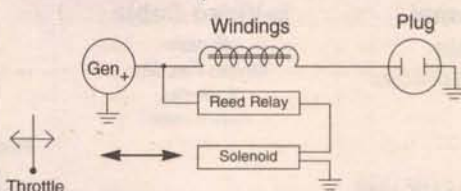
**2976** **John Ringle**  
**Tech Research Lab**  
**Harshaw, WI**

## ANSWERS

### ANSWER TO #1974 - JAN. 1997

The easiest way to control the speed on your generator is with the help of a sensing circuit and throttle control solenoid. You can fabricate a sensing circuit with about 10 to 15 windings of lacquered 12-gauge wire looped around a metal bar (1/4" diameter) and a glass reed switch glued (silicone) to the windings.

All of the generator's AC power goes through this winding assembly and over to the outlet to deliver the voltage to the accessory you're trying to run. When there is no load going through these windings, there is no magnetic field produced because the circuit is open, and thus the reed switch is off. When a load is connected to the AC receptacle, all of that load goes through the windings producing a small electromagnetic field capable of pulling the reed switch together and this, in turn, is the control circuit for your throttle solenoid. The reed switch powers the solenoid, which pulls the throttle to the "on" position, which has been predetermined by you and is adjustable when the load has been removed. The magnetic field collapses, the reed switch shuts off, the solenoid fails, and the throttle returns to idle. The wire size of the windings must be the same size or larger as those used to feed the receptacle.



**Chris Smith**  
**Bieber, CA**

### ANSWER TO #1978 - JAN. 1997

The "Power OK" signal is an output from the PC supply that is used by the motherboard to indicate that the +5 VDC output is stable and ready to be used. It must be held at a logic low state for at least 100 ms after the supply's +5 VDC output is stable. When the +5 is ready, the signal goes to a logic high state (some supplies require an external pull-up resistor, courtesy of the motherboard). For best results, limit the active low state to two seconds or less (to keep reset time to a minimum).

The Power OK signal is used by the motherboard to hold the processor reset until the supply voltage is stable. This is especially important during the start-up times of the supply, since

the supply may take several hundred milliseconds to obtain a clean (regulated) output. If the processor was allowed to start too early, unreliable boot-up is possible, as well as CMOS RAM corruption.

You can simulate the signal using any typical microprocessor reset circuit. For the ultimate design, consult the MAXIM data book for one of their many custom reset ICs.

You may also connect a pushbutton switch from this signal to ground (logic ground) to provide a nice external reset button on PCs that have none.

**Thomas E. Black**  
**Folsom, CA**

### ANSWER TO #1975 - JAN. 1997

The time signal sent by WWV 5, 10, 15, and 20 MHz contains a 100 Hz subcarrier encoded with a BCD (binary coded decimal) representation of the year, Julian date, hour, minute, and several other bits of technical data (Daylight Savings Time, UT1 correction value, etc.).

This data is also sent by the low-frequency station WWVB which broadcasts on 60 KHz. This latter frequency is not subject to the propagation vagaries of the HF channels. The WWVB transmitter is now being upgraded in power by a factor of four. Consequently, it should soon be easily receivable all over the continental US. This is expected to spark sale of, for example, watches and VCRs which set themselves to the correct time automatically.

The format of the WWV/WWVB data is described in NIST Special Publication 432, it is a slight modification of the standard IRIG-B format used by laboratory equipment. You can write to NIST at Boulder CO, 80303-3328, however, NIST SP 432 is also available on-line at: <http://www.bldrdoc.gov/timefreq/pubs/sp432>

This contains both text and graphical descriptions of the BCD Time Format.

A simple decoder could be built from a low-pass filter, a 567 tone decoder tuned to the 100 Hz data signal, and a BASIC Stamp microprocessor to do the data conversion — hook this to an LCD display using one of Scott Edwards LCD Backpacks and there's your clock!

**G. R. Scott**  
**Alexandria, VA**

### ANSWER TO #1972 - JAN. 1997

The reader is on the right track for satellite weather reception, however, a conventional (C-band) satellite receiver

## ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be paid within four weeks of publication if your answer is printed.
- Only one answer per question will be printed.
- If you do not want your name, address, or phone number available to the reader please so indicate or it will be assumed that you have no objection.
- In the event that more than one person submits the same solution, the choice will be made at the discretion of the publisher.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.

## QUESTION INFO

### TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:

- 1) Circuit Design
- 2) Electronic Theory
- 3) Problem Solving
- 4) Other Similar Topics

### INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

### HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

is not the final piece of equipment he needs. A low-cost home satellite reception system usually consists of a 1691 MHz antenna (typically a small dish or a Yagi of some type), a preamplifier mounted at the antenna, a downconverter, then a modified scanner or dedicated satellite weather receiver. (The scanner modification is to enable reception of the wideband satellite signal.) You will frequently see the downconverter output set at 137 MHz. This is to enable use of the same receiver, without a different antenna, to receive images from low-orbiting weather



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18VAC, 300mA, Wall Transformers (Perfect for Stealth Units)	50 pcs. - \$3.00@	100 pcs. - \$2.50@	250 pcs. - \$2.00@
4 Mhz Resonators, 3 pins	100 pcs. - \$.50@	500 pcs. - \$.45@	1,000 pcs. - \$.41@
8 Mhz Crystals, 2 pins	100 pcs. - \$.50@	500 pcs. - \$.45@	1,000 pcs. - \$.41@
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## TECH FORUM

satellites which broadcast on that frequency, using the same data format as the geosynchronous satellites on 1691 MHz.

The audio output from the scanner or receiver is typically fed to a computer to generate the final weather image. If the reader thought it was possible to display the weather image directly on a TV set, that is unfortunately not possible. The weather image is sent in a format that is quite different from a television video signal, taking many seconds to build a complete image.

Universal Radio stocks several books on satellite reception (1-800-431-3939) as does Grove Enterprises 1-800-438-8155; of particular interest may be *The Weather Satellite Handbook* by Ralph Taggart. Another resource is the *ARRL Satellite Experimenter's Handbook* (available from several *Nuts & Volts* advertisers). Mr. Taggart has also published numerous articles on low-cost satellite reception — a search for his name in a periodical index will turn up a lot of satellite related articles.

G. R. Scott  
Alexandria, VA

### ANSWER TO #1971 - JAN. 1997

A directional antenna may be constructed with a ferrite rod and amplifier as shown in Figure 1. A ferrite rod

5/16 inches in diameter and 7 inches long was wound with 90 turns which gave sufficient inductance (about 300 uh) to cover the AM band without tuning and gave good reception well into the shortwave band. Experiment with whatever loopstick is available, but larger is better.

The MC1590 differential amplifier to the outside wall of the house with

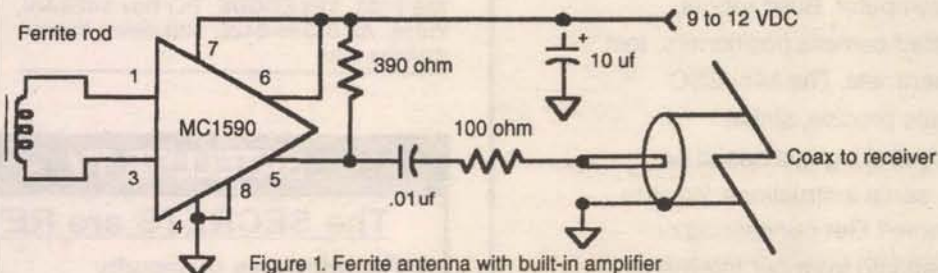


Figure 1. Ferrite antenna with built-in amplifier

may be constructed on a small piece of copper-clad circuit board material using the copper board for ground connections. The amplifier should be mounted near the ferrite loopstick with the coax and power wire leading to the radio. No separate ground wire is shown since the coax shield will serve both purposes. The loopstick and amplifier may be slipped into a piece of 1-3/8 inch PVC with a cap on one end and a right angle coupling and pipe on the other (Figure 2).

The vertical pipe may be secured

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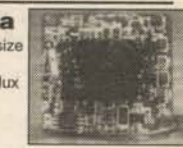
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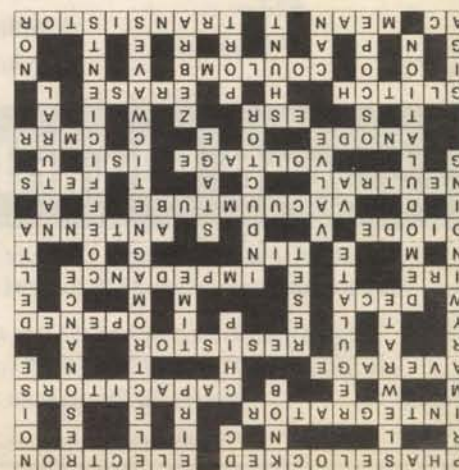
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of foaming urethane caulking could be used to seal the pipe. Ground the coax to the cold water pipe for lightning protection if the loop is outside.

Charles Wenzel  
Austin, TX

### Solution to Electronics Puzzle on Page 75





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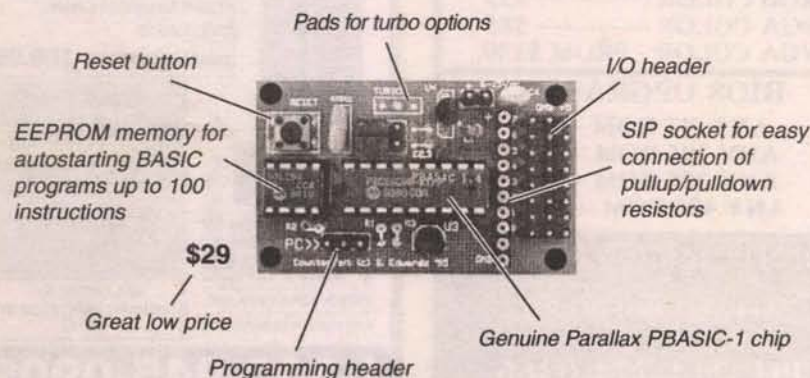


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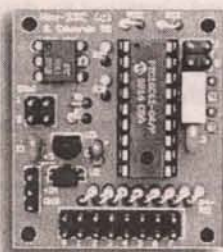
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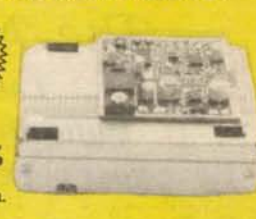


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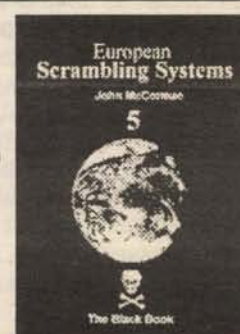
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**Supertronix**  
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Kent 98032

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**ESN READER** connects between AR3000 or PRO-2006 scanner and personal computer, reads and logs to disk. Scanner and computer not included. \$995 US postal money order to Keith Perry, PO Box 816, Leander, Texas (78641). SASE for info. 512-259-4770.

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Handheld, battery operated.

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• 12/115V

• Science Project

LAS1KM 1 mw, low cost Kit ..... \$69.50

LGU6K 2-3mw Kit ..... \$119.50

HNE70 5-7mw, ready to use ..... \$299.50

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Star Wars technology demonstrates weapons potential. IOG7K Kit/Plans \$99.50

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10-14" of Explosive Bolts of Lightning!

• Transmit Wireless Energy

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• Anti-Gravity

• Strange and bizarre pyrotechnical effects

• Many other experiments shown in detail

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Levitate an object!

Great science fair project!

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GRA10 Assbld Kit/Plans ..... \$149.50

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Spectacular color. Pulsates to music, sounds! 8-9", with intensity and sound controls. PLASMA1 Ready to Use ..... \$79.50

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.....shown connected to potential rail gun system

**Solid State Tesla Coil**

• Generate fiery electrical plasma discharge

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TCL5K Kit/Plans 12VDC ..... \$49.50

**Electronic Hypnotizer**

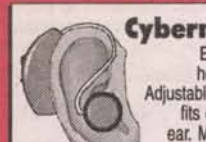
Control their minds! Programmable audible and visual stimuli induces hypnotic trances. HYP2K Kit with Book ..... \$39.95

EH2 Hypnosis Book & Plans ..... \$14.95

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Enhances normal hearing 3-4 times!

Adjustable volume control, fits easily into either ear. Many, many uses.

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• Tune-able 80-130 Mhz • Undetectable

• Only transmits when phone is used

VWPM7K Kit/Plans ..... \$39.50

### Extended Play Telephone Taping System

• Tapes Phone Conversation • Extends Tape X4 • Check Local Laws before using!

TAP30X Ready to Use ..... \$84.50

### 3 Mi Tracker Transmitter

• Tunable Output

• Uses FM Radio

• Excellent Signal Beacon

HOD1K Kit/Plans ..... \$39.50

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Aim at window and listen to sounds from reflected light. CAUTION - Not for illegal use. LWB3 Plans ..... \$10.00

LWB3K Kit/Plans (req's vid tripod) ..... \$149.50

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Use tone phone anywhere in the world to:

• Monitor your premises - avoid break-ins

• Access ongoing calls - longwinded kids

• Control up to 8 appliances in your home!

• Re-direct costly toll calls from pay phones!

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TELCON3K Plans/Kit ..... \$99.50

TELCON30 Ready to Use ..... \$149.50

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• Ultra-Sensitive Mike

• Crystal Clear

• Tunes 80-130 Mhz.

FMV1K Kit/Plans ..... \$39.50

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Easily tunable over FM radio. Never needs battery! #DROPIN Kit/Plans ..... \$19.95

### MIND CONTROL!

Places subjects under your control. Programmable audible & visual stimuli with biofeedback. Induces strange & bizarre hallucinations without drugs. Caution - not FDA approved.

MIND2 Plans ..... \$15.00

MIND2K Kit and Plans ..... \$49.50

MIND20 Assembled Unit ..... \$69.50

### Long Range "Ultra-Ear"

20" dish uses satellite technology to capture distant sounds. PMS Plans ..... \$8.00

PM5K Kit/Plans ..... \$149.50

• Optional Wireless Retrofit transmits captured sounds to an FM radio.

WM5K Kit for Wireless Option ..... \$29.50

### FireBall Gun

Shoots flaming ball - two shot capacity. Great for special effects and remote fire starting. CAUTION REQUIRED!

FIREBALL Plans (dangerous product) ..... \$10.00

### See In Total DARKNESS!

• High Quality IR Night Vision Scope with IR illuminator.

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### FANTASTIC BRIGHTNESS!

High Quality Laser Pointer

LAPN64 15mw equiv, 2000' ..... \$39.50

LAPN61 50mw equiv, 4000' ..... \$84.50

### 1000' Potato Cannon

Not a Toy! Uses electronic or piezo ignition. CAUTION REQUIRED!

POT1 Plans (dangerous product) ..... \$10.00

### Parabolic Mic can hear a distant whisper! BUG Mother Nature!

20" dish uses satellite technology to capture distant sounds. PMS Plans ..... \$8.00

PM5K Kit/Plans ..... \$149.50

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Rids areas of unwanted pests. Trains and conditions wild and domestic animals. Great for barns, attics, cellars, gardens.

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Don Lancaster's

# RESOURCE BIN

number sixty one

## A few of my favorite web sites.

Our usual reminder here that the *Resource Bin* is a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja* questing, personal publishing, money machine, or computer topic by calling me at (520) 428-4073 weekdays 8-5 Mountain Standard Time.

### Some Favorite Web Sites

This month, I thought we'd review a few of my preferred or most used web sites.

The web really makes things easier than they used to be. I recently got a loan of an impressive new PostScript speaking (!) *PowerScript* PS-1000 video character generator from the *Videonics* people. At [www.videonics.com](http://www.videonics.com) — At any rate, I did want to feature this in my current *Tech Musings* column. Along with a general tech backgrounder on video and NTSC.

Uh, whoops. A few months back, I found something somewhere obscure about a new video fading circuit, but ignored it at the time. And because I subscribe to some 500+ trade journals, pinning it down as hard copy seemed futile. A quick visit to the "search all web sites at once" at [www.lookup.com](http://www.lookup.com), followed by two trade journal sites at [www.electronicproducts.com](http://www.electronicproducts.com) and at the [www.eet.com](http://www.eet.com) quickly told me this chip is a *Linear Technology* LT1251.

Bouncing on over to [www.linear.com](http://www.linear.com) gave me a quick download with full tech details on this exciting chip.

More info on this *Videonics* cg and the *Linear Technology* LT1251 can be found in *MUSE110.PDF*.

### Finding Good Web Sites

Just how do you find out where the better sites are buried? Certainly by recommendations from your friends, by reading ads, and printed editorial mentions. There's a dozen or so new Internet mags that offer hundreds of new site listings each month. We saw more on these back in *RESBN55.PDF* and

*RESBN56.PDF*.

A second route is to sample one of those services that feature the 500 best sites. Such as those you might find at [www.cciweb.com](http://www.cciweb.com) — *way500/* or [www.cio.com/Web-Master/lm\\_frontpage.html](http://www.cio.com/Web-Master/lm_frontpage.html) — Another ploy is to use the *avalanche effect* where you always check the *surf other sites* hot button on each site you drop in. Theoretically, each and every web site is within *seven* or so mouse clicks from each other. So by linking a link to a link, you can end up nearly anywhere you like.

Pay particular attention to *gateway sites* which have lots of definitive and well annotated links.

But the best way I've found to pin down new sites is using the good old Yahoo dice at [www.yahoo.com](http://www.yahoo.com) — Each hit jumps you *somewhere* in cyberspace. Run

### NEXT MONTH: Don shows us an alternate method to find new trade journals.

your own *avalanche effect* three or four clicks deep, and you can end up nearly anywhere.

### Technical Sites

You'll find the *Nuts & Volts* web page at [www.nutsvolts.com](http://www.nutsvolts.com) — Included is a FTP library with scads of shareware, source code, columns, and other info. There's also the Events Calender, back issues, writer's guidelines, subscription services, and bunches more.

Other resources of technical interest include both *PE* and *EN* magazines at [www.gernsback.com](http://www.gernsback.com); Jeff Duntemann's *Visual Developer* at [www.coriolis.com](http://www.coriolis.com); Try Steve Ciarcia at [www.circellar.com](http://www.circellar.com); Dave Baldwin's fine *Computer Journal* at [www.psyber.com/~tcj/](http://www.psyber.com/~tcj/); that *Recharger* magazine at [recharger-mag.com](http://recharger-mag.com); or Jeff Anderson's *Home Automator* located at [www.automator.com](http://www.automator.com); and Richard and Karen Perez's *Home Power* you should find at [www.homepower.com](http://www.homepower.com)

My own site is [www.tinaja.com](http://www.tinaja.com) My intent is to include most of those cyber resources and tools that I

actually need and use. The thinking being that, if I find them useful, the chances are that others just might as well.

The online reference library is arranged by *shelves*. These include *Math Stuff*, *Tech Musings*, *Blatant Opportunist*, *Resbin*, *Cubic Spline*, *Book-on-demand*, *Tinaja Questing*, *Flutterwumper*, *Guru's Lair*, *Hardware Hacker*, *Magic Sinewave*, *PIC Pecking*, *Navicube*, *PostScript*, *Patent Avoidance*, *Other*, *ISMM*, *Pseudoscience*, *Synergetics*, *Tech Musings*, *Third Party* and *Webmastering* topics.

You'll also find plenty of annotated site links, a few newsgroup links, that *Synergetics Consultant's Network*, my online catalogs, that surplus bargain page, and a tech forum. Plus a handy online library for third party authors. Such as Scott Edwards, Jim Dubois, and Jim Fitzsimmons.

All the big engineering firms, major semiconductor houses, trade journals, and distributors have web sites. Most of these chip manufacturers seem to be trying to get away from hard copy data books. CD-ROM and Adobe Acrobat 3.0 online distribution are becoming the norm.

Since there's hundreds of EE sites, I'll save you lots of typing by sending you instead to all their annotated hot links on [www.tinaja.com](http://www.tinaja.com)

### Individual Sites

Here's some labor-of-love locations that I am really impressed with: John Simonton's *Paia Electronics* electronic music site at [www.paia.com](http://www.paia.com); try Steve Hansen's *Bell Jar* high vacuum stuff at [www.tiac.net/users/shansen/bell-jar](http://www.tiac.net/users/shansen/bell-jar); Frank Miller's direct toner method printed circuitry at [www.dynaart.com](http://www.dynaart.com); and Eric Smith's *PIC Projects* found at [www.brouha.com/~eric/pic/](http://www.brouha.com/~eric/pic/) — Check out Eric's OJ Simpson detector!

See Seth Friedman's *Factsheet Five* over at [www.well.com/f5/f5index2.html](http://www.well.com/f5/f5index2.html) — His guide to underground 'zines has got something to offend everyone.

Shawn Carlson writes that *Amateur Scientist* column in *Scientific American*. He also honors the *Society of Amateur Scientists*. You'll find his SAS web site at [www.thesphere.com/sas/](http://www.thesphere.com/sas/) — Steve Roberts is into nomadics and human-powered vehicles in one really big way. Such as recumbent bicycles, catamarans, submarines, or whatever. His web location is [www.microship.com](http://www.microship.com) — Look there for newsletter details.

Tim Jenison runs *NewTek*; home of the *Video Toaster*, *Video Flyer*, and his *Lightwave* software now available for all major platforms. Tim's site can be found at

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The sixteenth (!) printing of Don's bible on analog op-amp lowpass, bandpass, and highpass active filters. De-mystified instant designs. \$28.50

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### LOTS OF OTHER GOODIES

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Hardware Hacker II, III or IV .....	\$24.50
Micro Cookbook I .....	\$19.50
PostScript Beginner Stuff .....	\$29.50
PostScript Show and Tell .....	\$29.50
Intro to PostScript Video .....	\$29.50
PostScript Reference II .....	\$34.50
PostScript Tutorial/Cookbook .....	\$22.50
PostScript by Example .....	\$32.50
Understanding PS Programming .....	\$29.50
PostScript: A Visual Approach .....	\$22.50
PostScript Program Design .....	\$24.50
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### RESOURCE BIN I

A complete collection of all Don's *Nuts & Volts* columns to date, including a new index and his master names and numbers list. \$24.50

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Check Don's *Guru's Lair* at <http://www.tinaja.com> for interactive catalogs and online samples of Don's unique products. Searchable reprints and reference resources, too. Tech help, hot links to cool sites, consultants. email: [don@tinaja.com](mailto:don@tinaja.com)

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# RESOURCE BIN

## SOME FAVORITE WEB LINKS

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 Amazon Books — [www.amazon.com](http://www.amazon.com)  
 Bed and Breakfast Guides — [www.homearts.com/affil/ahi/main/ahihome.htm](http://www.homearts.com/affil/ahi/main/ahihome.htm)  
 Bell Jar Newsletter — [www.tiac.net/users/shansen/belljar](http://www.tiac.net/users/shansen/belljar)  
 Black Range Lodge — <mailto:blackrange@zianet.com>  
 Blond redneck Aggie lawyers — [www.winn.com/pwinn/humor/index.html](http://www.winn.com/pwinn/humor/index.html)  
 Church of the Subgenius — [sunsite.unc.edu/subgenius](http://sunsite.unc.edu/subgenius)  
 Circuit Cellar magazine — [www.circellar.com](http://www.circellar.com)  
 Classifieds 2000 Cool Notify cars — [www.classifieds2000.com](http://www.classifieds2000.com)  
 Computer mags — [www.netvalley.com/netvalley/top100mag\\_defgh.html/#h](http://www.netvalley.com/netvalley/top100mag_defgh.html/#h)  
 Computer Journal magazine — [www.psyber.com/~tcj/](http://www.psyber.com/~tcj/)  
 Dilbert and Dogbert — [www.unitedmedia.com](http://www.unitedmedia.com)  
 Don Lancaster's Synergetics — [www.tinaja.com](http://www.tinaja.com)  
 Dynaart Designs — [www.dynaart.com](http://www.dynaart.com)  
 E. E. Times Magazine — [www.eet.com](http://www.eet.com)  
 Electronic Products Magazine — [www.electronicproducts.com](http://www.electronicproducts.com)  
 Emory University Med Web — [www.gen.emory.edu/medweb](http://www.gen.emory.edu/medweb)  
 Eric Smith's PIC Projects — [www.brouhaha.com/~eric/pic/](http://www.brouhaha.com/~eric/pic/)  
 Ezines list — [www.meer.net/~johnl/ezine-list/](http://www.meer.net/~johnl/ezine-list/)  
 Factsheet Five magazine — [www.well.com/f5/f5index2.html](http://www.well.com/f5/f5index2.html)  
 Family oriented kiddy site — [www.bess.net](http://www.bess.net)  
 Film review site — [www.film.com](http://www.film.com)  
 Flying Pig Site — [www.randi.org/jr/](http://www.randi.org/jr/)  
 Fodor's — [travel.epicurious.com/travel/b\\_places/05\\_bnb.html?63106](http://travel.epicurious.com/travel/b_places/05_bnb.html?63106)  
 Free catalogs — [www.halcyon.com/2001/](http://www.halcyon.com/2001/)  
 Free newsletters — [pub.savvy.com/subject.html](http://pub.savvy.com/subject.html)  
 Galt stock quotes — [quotes.galt.com](http://quotes.galt.com)  
 Great Outdoor Recreation Places — [www.gorp.com](http://www.gorp.com)  
 Home Automator magazine — [www.automator.com](http://www.automator.com)  
 Home Power magazine — [www.homepower.com](http://www.homepower.com)  
 Internet Movie Database — [us.imdb.com](http://us.imdb.com)  
 I-way magazine — [www.cciweb.com/iway500/](http://www.cciweb.com/iway500/)

Job locator — [www.datamation.com/PlugIn/jobs/jobs.html](http://www.datamation.com/PlugIn/jobs/jobs.html)  
 KeelyNet pseudoscience — [www.keelynet.com](http://www.keelynet.com)  
 Linear Technology — [www.linear.com](http://www.linear.com)  
 Master web searcher — [www.lookup.com](http://www.lookup.com)  
 Medical Access — [www.medaccess.com](http://www.medaccess.com)  
 More wilderness lodges — [www.inns.com/nm.html](http://www.inns.com/nm.html)  
 Netscape Gold — [www.netscape.com](http://www.netscape.com)  
 NewTek video toaster — [www.newtek.com](http://www.newtek.com)  
 Nuts & Volts magazine — [www.nutsvolts.com](http://www.nutsvolts.com)  
 Paia Electronics — [www.paia.com](http://www.paia.com)  
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 PE and EN magazines — [www.gernsback.com](http://www.gernsback.com)  
 Quaint inn guide — <http://www.incrawler.com/>  
 Quick stock quotes — [www.quote.com](http://www.quote.com)  
 Playboy stock quotes — [fast.quote/fq/playboy/quote?adbe.aapl](http://fast.quote/fq/playboy/quote?adbe.aapl)  
 Recharger magazine — [rechargermag.com](http://rechargermag.com)  
 Review site at Film Zone — [www.filmzone.com](http://www.filmzone.com)  
 Roberts nomadics & human power vehicles — [www.microship.com](http://www.microship.com)  
 Saucer Smear magazine — [www.mcs.com/~kvg/smear.htm](http://www.mcs.com/~kvg/smear.htm)  
 Science Hobbist — [www.eskimo.com/~billb/](http://www.eskimo.com/~billb/)  
 Skeptical Inquirer magazine — [www.csicorp.org](http://www.csicorp.org)  
 Society of Amateur Scientists — [www.thesphere.com/sas/](http://www.thesphere.com/sas/)  
 Stevie Site clip art — [www.stevie.com/cgi-bin/STEVIE/stev\\_graphics](http://www.stevie.com/cgi-bin/STEVIE/stev_graphics)  
 Telephone directory — [www.lookup.com/Home/pages/73107/search.html](http://www.lookup.com/Home/pages/73107/search.html)  
 UFO links gateway — [www.io.com/~sheol/ufo.html](http://www.io.com/~sheol/ufo.html)  
 US government surplus sales — <http://131.87.1.51/>  
 Videonics PostScript cg's — [www.videonics.com](http://www.videonics.com)  
 Visual Developer magazine — [www.coriolis.com](http://www.coriolis.com)  
 Wall Street Research Network — [www.wsrn.com](http://www.wsrn.com)  
 Webmaster magazine — [www.cio.com/WebMaster/lm\\_frontpage.html](http://www.cio.com/WebMaster/lm_frontpage.html)  
 Wilderness lodge guide — [cimarron.metronet.com/index.html](http://cimarron.metronet.com/index.html)  
 Yahoo dice hypersurfer — [www.yahoo.com](http://www.yahoo.com)

[www.newtek.com](http://www.newtek.com) — Chip Gracey runs *Parallax*, home of the *BASIC Stamp* and other PIC goodies. The full set of *BASIC Stamp Application Notes* are at [www.parallaxinc.com](http://www.parallaxinc.com) — Note that [www.parallax.com](http://www.parallax.com) is a different url run by somebody else.

### Useful Tools

A major resource for pinning down book info is *Amazon Books*. Located at [www.amazon.com](http://www.amazon.com) they are vastly more convenient than *Books in Print*.

One excellent telephone directory is *Lookup USA* at [www.lookup.com/Homepages/73107/search.html](http://www.lookup.com/Homepages/73107/search.html) — I especially do like their map feature that shows you exactly how to get to the number you have just looked up.

Surplus US government sale info is at <http://131.87.1.51/> straight from the horse's whatever, even.

Free newsletters and free catalogs from thousands of sources are offered by [pub.savvy.com/subject.html](http://pub.savvy.com/subject.html) or from [www.halcyon.com/2001/](http://www.halcyon.com/2001/) — Extensive listings for ezines appear on [www.meer.net/~johnl/ezine-list/](http://www.meer.net/~johnl/ezine-list/)

Links to the top 100 computer mags are at [www.netvalley.com/netvalley/top100mag\\_defgh.html/#h](http://www.netvalley.com/netvalley/top100mag_defgh.html/#h)

An impressive collection of 15,000 clip art subjects useful for site design can be found through the *Stevie Site* at [www.stevie.com/cgi-bin/STEVIE/stev\\_graphics](http://www.stevie.com/cgi-bin/STEVIE/stev_graphics) good stuff here.

Buying or selling a car is amazingly easy using that *Cool Notify* feature of *Classifieds 2000*, whose site is found at [www.classifieds2000.com](http://www.classifieds2000.com) — But I am still having difficulty finding a clean VW *Synchro*. A finder's fee if you can help me out here or perhaps a free *tinaja quest* to one of those places you can only get to in a 4WD *Synchro*.

### Investments

A big warning here: Anybody can start up a web page and then tell you anything they like. Including selling, recommending, or promoting stocks, and ripping you off. So, always check out multiple sources for any investment information. Every time.

One major gateway site to nearly all credible investment stuff is that *Wall Street Research Network*. Find this site at [www.wsrn.com](http://www.wsrn.com) — You will find tens of thousands of links here.

My favorite source for quick stock quotes with detailed price histories is at [www.quote.com](http://www.quote.com) — But these folks will typically charge sponsoring web sites for their fancier services.

I do use their freebie *Playboy* link at [fast.quote/fq/playboy/quote?adbe.aapl](http://fast.quote/fq/playboy/quote?adbe.aapl) — This service does have five minute delayed price quoting and does hang up badly during busier times. As its back-up, I use an alternate and slightly less convenient [quotes.galt.com](http://quotes.galt.com)

### Jobs

There are several dozen useful job locator sites. One gateway link to a lot of these is *Datamation* magazine: [www.datamation.com/PlugIn/jobs/jobs.html](http://www.datamation.com/PlugIn/jobs/jobs.html) — And, of course, alternatives to full time jobs are located in my *Incredible Secret Money Machine*.

### Pseudoscience

I have long been utterly fascinated by pseudoscience. Mesmerizingly awful "research" on such topics as perpetual motion (or "overunity energy"), 1,000 MPG cars, antigravity, Area 51, rampant Teslaism, UFOs, psychic powers, and miracle medicines.

Scams aside, pseudoscience

usually results from either (A) bad or missing lab work which is not even wrong; or (B) not having the skills and tools to understand the problem.

One of my goals around here is to pile up all pseudoscience on center stage, shine a bright light onto it, and get you to personally conclude "Yup — that sure is a big pile all right." Which is why I've placed bunches of the pseudoscience links and bizarre downloads onto my [www.tinaja.com](http://www.tinaja.com) — I even gave it a private library shelf.

I cannot fathom how anyone could possibly be stupid enough to believe that unlimited free energy is useful or even remotely desirable.

Unlimited free energy would be far and away your most heinous possible crime against humanity. This would rapidly turn the planet to a cinder.

### Instant Toast

At any rate, the "best of the worst" pseudoscience is up on Jerry Decker's KeelyNet at [www.keelynet.com](http://www.keelynet.com) — They've even made me their resident skeptic.

Your finest one stop flying saucer location is Thomas L. Wellborne II's *UFO Links* at [www.io.com/~sheol/ufo.html](http://www.io.com/~sheol/ufo.html) — One prime example of superb "in your face" muckraking journalism is James Mosley's *Saucer Smear* found at [www.mcs.com/~kvg/smear.htm](http://www.mcs.com/~kvg/smear.htm) — For a well done site that includes a rich mix of both real and fake science, do not miss William Beaty's *Science Hobbist* at [www.eskimo.com/~billb/](http://www.eskimo.com/~billb/) — And, on the other side of the fence, check out the Amazing Randi's *Flying Pig Site*, where \$640,000 is available to anyone that is able to convincingly demonstrate dowsing or pretty near any other psychic technique. The site is [www.randi.org/jr/](http://www.randi.org/jr/) — And, of

course, there is always that good old *Skeptical Inquirer* site at [www.csicorp.org](http://www.csicorp.org)

### Humor

The Guru's and Swami's local 204 union rules demand that all technical web sites have a Dilbert and Dogbert link. To [www.unitedmedia.com/](http://www.unitedmedia.com/) especially liked that strip where Dogbert the programmer replies "It's not my fault. Some mil guy named General Protection did it."

Didja hear the one about the blond redneck Aggie lawyer who ... Details can be found on [www.winn.com/pwinn/humor/index.html](http://www.winn.com/pwinn/humor/index.html) — I was reading a WWII book recently that included this curious historical footnote: Supposedly one of the last US Marines to perish in the war was "Spammed" to death when the supply parachute failed to open on a POW relief aid mission.

Which is apparently the very first instance of Spamming. I guess we can skip the web page that specializes in pornographic Spam Haiku's. I seem to have misplaced its url.

Actually, if you search *Alta Vista* on "Spam Haiku," you are guaranteed to be utterly appalled by those 9000 site hits you will receive. No joke.

### And a Few More ...

Wilderness lodges and quaint inns can be found at Deborah Sakach's *Bed and Breakfast Guides* at [www.homearts.com/affil/ahi/main/ahihome.htm](http://www.homearts.com/affil/ahi/main/ahihome.htm) — Four alternate sources here include [cimarron.metronet.com/index.html](http://cimarron.metronet.com/index.html); <http://www.incrawler.com/>; or *Fodor's* at [travel.epicurious.com/travel/b\\_places/05\\_bnb.html?63106](http://travel.epicurious.com/travel/b_places/05_bnb.html?63106) And finally check out [www.inns.com/nm.html](http://www.inns.com/nm.html) — My own chosen wilderness retreat is the *Black Range Lodge* where you'll find Frisbee champion levitating UFO aliens busily editing straw bale home videos while cooking in a horno. Uh, that's on an ordinary day when things don't get too strange.

Craftily hidden in the part of New Mexico that you can't get to. Er, their web site is not quite on line yet. But E-Mail them at [blackrange@zianet.com](mailto:blackrange@zianet.com) — Meet me there some day. To scam your company into sending you there free, see MSINPROP.PDF on the Magic Sinewave shelf of [www.tinaja.com](http://www.tinaja.com)

For an outdoor and wilderness area web site I like, look at *Great Outdoor Recreation Places* at [www.gorp.com](http://www.gorp.com)

One family oriented and "G" rated kiddy site is up at [www.bess.net](http://www.bess.net) Bess, of course, is a





retriever. Amazingly, Bess often leads to some surprisingly sophisticated research sites.

For instance, click *science and nature*, then *other good science sites*, then that *electronic zoo*, then *animals*, then *cows*. Then your choice of *dairy* or *beef*. And observe *nearly a thousand* professional, commercial, and scientific links telling you far more than you could possibly ever want to know about bovines.

Of the many medical web locations, two I like are Emory University's *Med Web* at [www.gen.emory.edu/medweb](http://www.gen.emory.edu/medweb) and *Medical Access* at [www.medaccess.com](http://www.medaccess.com) — What you really want to watch for are *Medline* links. Which is a premium service that the doctors all use. Free access (with some minor restrictions) to Medline are now newly offered by a dozen or so sites.

There's scads of movie review sites. Three I prefer are *Internet Movie Database* at [us.imdb.com](http://us.imdb.com); [www.film.com](http://www.film.com); or [www.filmzone.com](http://www.filmzone.com) — Last and quite possibly least, why think international while you can go completely off the planet instead? Do check out the finest and foremost web religion ever. At the J.R. "Bob" Dobbs *Church of the Subgenius*. It is found at [sunsite.unc.edu/subgenius](http://sunsite.unc.edu/subgenius). This one is way beyond, beyond.

## This Month's Contest

For our contest this month, simply send me a listing of your favorite web sites. Preferably obscure ones I have never heard of. And tell me how you found them and why you like them.

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your *written* entries to me here at *Synergetics*, rather than to *Nuts & Volts* editorial. **NV**

**M**icrocomputer pioneer and guru Don Lancaster is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don also offers a free catalog full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.

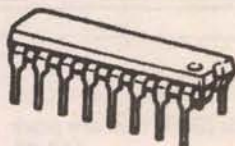
You can reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of [don@tinaja.com](mailto:don@tinaja.com)

## COMPONENTS cont.

**ELECTRONIC PARTS** catalog two stamps. Dan's Small Parts, Box 3634, Missoula, MT 59806. Ph/Fax 406-258-2782. Online catalog <http://www.fix.net/dans.html>

**I WANT** it and I want it now. I want all of your SIMM memory. IBM, Mac, new, used, even defective. I want it all. Highest \$ paid. Now selling memory. We can beat any printed price in Nuts & Volts. Call 1-800-4-MEMORY now! Voice/FAX.

**RESISTORS 20 FOR \$1.** Catalog \$1. Foreign add \$1. ZIPFAST, Box 12238, Lexington, KY 40581-2238.



**WANTED: EXCESS ELECTRONIC INVENTORIES, ICs, MEMORY, EPROMs, PALs, LEDs, CIRCUIT BOARDS, DIODES, AND TRANSISTORS. CALL ACTIVE MICRO, 310-494-4851 OR FAX 310-494-4913.**

**250 AMP DIODES** 400PIV pigtailed, \$9.95. 10 for \$80. 100 for \$695. Scott's Electronic Surplus 310-491-3181 FAX: 310-491-3182.

**RECOVER "SCRAP GOLD" from old computer junk.** Free information packet. Call 24 hours: 603-645-4772.

**MILITARY TRANSISTORS & DIODES & INTEGRATED CIRCUITS WANTED. ELECTRONIC MATERIAL INDUSTRIES 818-842-3539, FAX 818-845-3613.**

**RF TRANSISTORS**, tubes, electrolytics. MRF477, 2SC2879, 2SC1969, MC145106P, 2SC2075, MRF454, SRF numbers, tubes, 4CX250B, 6KG6A, 12D6Q, 6146W, 3-500 graphite, trimmers, all types. Westgate 1-800-213-4563.

**ELECTRONIC PARTS for sale:** For list, send SASE to A&A Engineering, 2521 W. La Palma, Unit K, Anaheim, CA 92801. You can also call 714-952-2114 or Fax 714-952-3280.

**WE BUY** gold plated parts, transistors, hybrids, ICs, diodes, circuit boards, patch panels, military pins, tantalum capacitors, relays, old test equipment and all types of electronic material. **GOLD'N WEST SURPLUS** in Corona. Ph: 909-340-1501, FAX: 909-340-1504. ASK FOR MARK.

## Learn by Example!

The PRIMER 8085 Based Microprocessor Training and Control System shows you how to program by example. Examples & exercises in the Self Instruction manual take you from writing simple programs to controlling motors. Start out in Machine language, then move on to Assembly, & then continue on with optional C, Basic, or Forth Compilers. This trainer can be used stand alone via the keypad and display or connected to a PC with the optional upgrade (\$49.95). The Upgrade includes: an RS232 serial port & cable, 32K of battery backed RAM, & Assembly/Terminal software.

### Examples Include:

- Measuring Temperature
- Using a Photocell to Detect Light Levels
- Making a Waveform Generator
- Constructing a Capacitance Meter
- Motor Speed Control Using Back EMF
- Interfacing and Controlling Stepper Motors
- Scanning Keypads and Writing to LCD/LED Displays
- Bus Interfacing an 8255 PPI (new)
- Using the Primer as an EPROM Programmer

The PRIMER is only \$119.95 in kit form. The PRIMER Assembled & Tested is \$169.95. Please add \$5.00 for shipping within the U.S. Picture shown with upgrade option and optional heavy-duty keypad (\$29.95) installed.

**EMAC, inc.**  
11 EMAC WAY, CARBONDALE, IL 62901  
618-529-4525 Fax 457-0110 BBS 529-5708  
World Wide Web: <http://www.emacinc.com>

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**Shipped Same Day COD**  
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**Plazac Sales, Inc.**  
**Sorry, no New Jersey sales.**

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Write in 79 on Reader Service Card.

**TEST DEVICES**, manuals and software. Call Jack at 313-384-3949. No Michigan sales.

**INTERESTED** in buying a small RF connector and related business. Please send details and asking price in confidence to: PO Box 827, Somers, CT 06071.



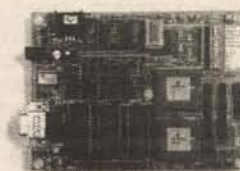
**MINIATURE TOGGLES 1/4" PANEL HOLE:** SPDT on-on 35¢. SPDT on-off-on 35¢. SPDT (mom)-off-on 35¢. DPDT on-on 40¢. DPDT on-off-on 40¢. DPDT (mom)-off-on 40¢. **MICRO-MINIATURE 3/16" HOLE:** SPDT on-on 30¢. DPDT on-on 40¢. Brand new switches. Rated 6A/125V. Hardware included. \$20 minimum order. Add \$5 freight. Gateway Products Corporation, PO Box 936397, Margate, FL 33093, 954-974-6864, Fax: 954-974-6818. VISA/MC. Free catalog.

**DON LANCASTER'S ACTIVE FILTER COOKBOOK** is back in print. Autographed copies of the seventeenth(!) classic printing \$28.50. **SYNERGETICS PRESS**, Box 809-N, Thatcher, AZ 85552. 520-428-4073. Visa/MC.

**ELECTRONIC COMPONENTS** bought. All resistors, diodes, resist, caps, ICs. Labb Assoc., Ph. 215-364-5414, Fax 215-364-5415.

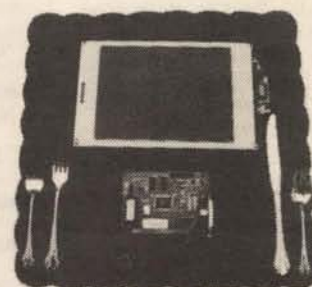
## MICROCONTROLLERS

**DALLAS 2250 CONTROLLER BOARD.** 8051 instructions, 32K memory, 30 I/O lines. Program from PC. Software included. 2.5"x4" double sided, solder masked PCB. Send \$49 to JW Peterson, 50935 Hill Drive, Elkhart, IN 46514.



**MICROCHIP PIC Downloader.** Emulate and test PIC 16C6x, 16C7x, and 16C8x programs in real time using our PicEm-14™ downloader board. Simply plug PicEm into your circuit and download your code from any serial port. Prices start at \$295. Call MSD at 408-296-4000. <http://www.msd.com/picem>

## VGA LCD's Served Here



### ROCK BOTTOM PRICES!

#### VGA LCD Controllers for PC ISA Bus

EarthLCD/M Monochrome LCD Controller \$160  
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#### NEW! Touch Screen Kits

Analog resistive touch screen with controller \$249  
**VGA Display Kits** include LCD, Controller, & Backlight  
7.4", 9.4", 10.4", 11.3" Starting at \$220  
Mono, Dual Scan & Active Matrix in Stock

#### Displays Only

Both new and surplus color displays from \$99  
**Digital LCD Monitors** Desktop LCD & ISA Controller  
Monochrome Monitors Starting at \$400  
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See Earth on the Worldwide Web! <http://www.flat-panel.com>

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Computer Technologies

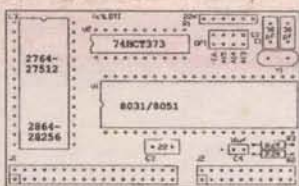
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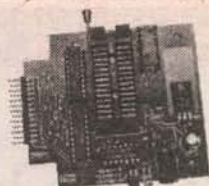
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February 1997 91





**8051 MICROCONTROLLER.** Only 1.8 x 3.0". Use EPROM or EPROM for data storage. Quality bare PCB, software, schematics, \$19.95. Kit \$29.95. Logical Design Tools, Inc. 512-888-4535. <http://www2.interconnect.net/ldti/hom.htm>



**EEPROM PROGRAMMER 2864-28256.** Easy parallel port operation. Escape EPROM erase/burn cycle. Assembled, complete. \$49.95. In 3 x 5" case \$69.95. LDTI 512-888-4535. <http://www2.interconnect.net/ldti/hom.htm>

**Closing Date For Next Issue — February 10th**

limited quantity remaining!

### HUGHES AML-STX-141 MICROWAVE TRANSMITTER with power supply

**\$150.00**



This professional quality high power microwave transmitter (2 watts) was originally used in the cable TV

industry to transmit cable channels to remote headends. They replaced these transmitter units with fiberoptic cable. The units are in good condition but we are unable to test them, so we are offering them 'AS-IS' for \$150.00 (that includes a power supply and connecting cables!) The transmitter units operate on 12,000 MHz and require 115VAC. Rack mount feature makes this a great addition to your system. Limited documentation available — we'll send you what we've got on 'em.

Approximate dimensions:

Transmitter 19" x 7" x 18.5"

Power Supply 19" x 5.25" x 15.25"

Please mention ad code NV0297 when ordering.

Mailorder customers should include an additional \$40.00 shipping and handling for this item.

### 127 THERMOCOUPLES

#### PELTIER JUNCTIONS

The peltier junction is a solid-state thermoelectric device. Current applied to the device will produce heat on one side of the device and a cold surface on the other side. Water placed on the surface will freeze or boil depending on polarity of applied voltage. Ideal for applications from 3-12 VDC — grab a battery and let your imagination run wild!

DOCUMENTATION INCLUDED!!!

Small Peltier Junction \$20.00

(approximately 1.17"x1.17"x.12")

Large Peltier Junction \$29.50

(approximately 1.56"x1.56"x.15")

### PHOTON MICROLIGHT

8 Candellas of bright red or yellow light, visible over a mile away! This super-bright LED is secured in a tough ABS case and runs on a 3V lithium battery (included!) It won't burn out because it is an LED! Incredible bright colors! Specify red, yellow, blue or green color when ordering. Battery has a 5 year shelf life and lasts up to 11 hours. (replacement battery \$0.98). Great for home or office

use, popular with fire and rescue professionals, pyrotechnicians, stage performers, and more.

red microlight \$10.00

yellow microlight \$10.00

blue microlight \$15.00

green microlight \$15.00

### 4-NUMBER AUTO DIALER



This four button unit allows you to preprogram telephone numbers (or DTMF codes) for quick dialing convenience. Tone or pulse selectable. Great for emergency numbers like police, fire, and ambulance (color coded buttons make selection simple) or simply to avoid memorizing the number to call for pizza, the pharmacy, or Aunt Matilda! Ideal for children's phone, elderly, or those with more to do with their time than to remember phone numbers! Approximately 4-1/4"x4-1/4"x1-3/4". Requires 9v battery (Duracell Included!!!) \$5.00

### PAN & TILT COLOR CAMERA WITH NO MOVING PARTS?!!?!!

A compact on-board camera with the capability to telephoto pan & tilt, zoom, and more...without the mechanical complications of a moving mount! Can be computer controlled throughout the RS-232 port to utilize additional features like fade, exposure, and balance. (User programming is required.) Great quality picture, this camera is ideal for security, stealth surveillance, keeping an eye on the kids, and more. Operates on 12VDC.

Approximate dimensions:

sp = 30mmX25mmX31mm

pc = 58mmX45mmX11mm

wt = 32g

Other useful specs:

exposure: electronic shutter auto iris

signal format: NTSC

lens: F2.4, f=4.7 (horiz. 45 degrees)

resolution: more than 300 TV lines

pixels: 510X492

\$350.00

please allow upto 3 weeks for shipment

### Passive Infra-red Talking Motion Detector III

**\$27.50**

"Stay out of that refrigerator!", "Watch your step!", "Do your homework!", "Don't touch that remote!" ... The possibilities are mind-boggling with this talking motion detector. You speak into it to record your message (upto 12 seconds long), turn the unit on, and instantly your voice (or your mother-in-law's) reminds anyone in the vicinity that you were expecting them. Message can be changed with the flip of a switch. Uses 4 AA batteries (not included), or an external power source (built-in jack). May be used independently (80 db output) or with an amplified speaker to blast your message throughout the house. Approx 4"x3-1/2"x1-1/2".



[www.gatewayelec.com](http://www.gatewayelec.com)

### BIG RED LED LIGHT BAR

**\$4.95**

High bright red LED light bar features 20 individual LEDs in a 16-1/2 inch long rod. Each LED is surrounded by a reflective cone making the already bright light even more impressive! Operates on 9-15 VDC. Neat package for cars, reading lamp, attention getting signs, cabinet accents, etc.

Approx. 16.5x1.25x0.5".



**HIGH SPEED MICROCONTROLLER** DC80C320 (8051 compatible), 64K-128K RAM, 64K-128K ROM, RS232, RS485, I2C EEPROM, RTC, parallel I/O (8255), AT keyboard input, 2-8 bit ISA slots, expansion header, LCD interface. Minimum system \$89, full system \$149. Free monitor/debugger. CG Microsystems, PO BOX 1074, Redlands, CA 92373. Voice/Fax 909-793-3917. <http://home.earthlink.net/~cgmicro/>

## ANTIQUE ELECTRONICS

**WESTERN ELECTRIC WANTED:** 1927-1960S. Amplifiers, speakers, tubes, etc. Free offer. 1-800-251-5454.

### New NiMH battery pack \$29.95

for your Motorola®  
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Charcoal gray  
1500mAh 6v battery pack  
with NiMH batteries.

-environmentally safe

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-no "memory"

-works with your  
standard charger

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### Matching Gear Set

**\$5.95**

Black plastic gears in five different sizes - all matched for interlocking precision. Set includes two gears in each tooth size, (10, 20, 30, 40, & 50) and ten center reduction collets (center size 3.75mm without collet, 2mm with collet.) Great for robotics, mechanical reduction, and many other applications!



approx. gear sizes: 2", 1-5/8", 1-1/4", 7/8", 1/2"

### HOW TO KEEP YOUR VCR ALIVE

**\$24.95**

Cleverly subtitled VCR REPAIRS ANYONE CAN DO, this book is one of our best sellers. This is probably true because you really don't have to read the whole book! Organized by symptoms, How To Keep Your VCR Alive is written in an easy-to-understand format without the usual technobabble. Illustrations and appendices provide additional help as you endeavor to keep your vcr up and running.

### AMAZING MINI MICRO FM RADIO!

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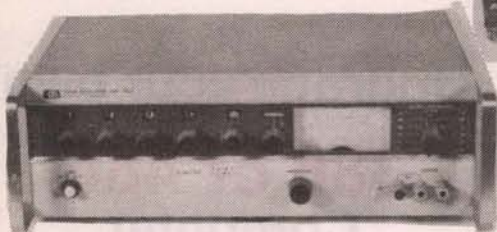
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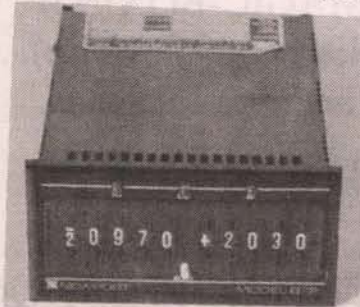
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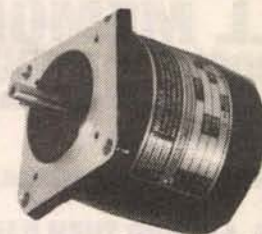
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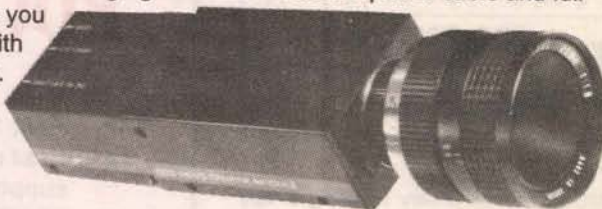


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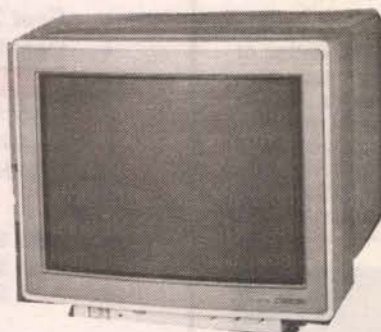
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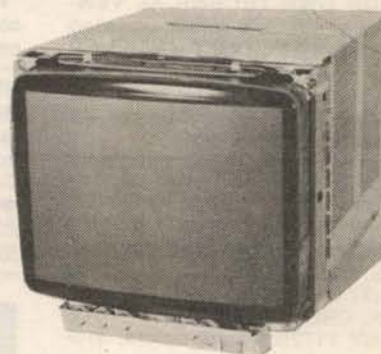
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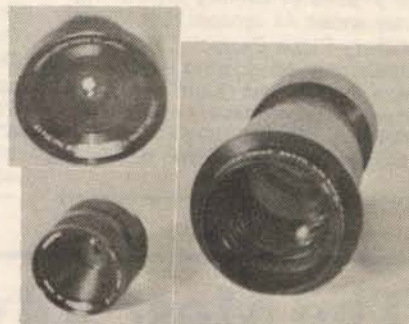
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# ELECTRONICS

## Q & A

..... With TJ Byers

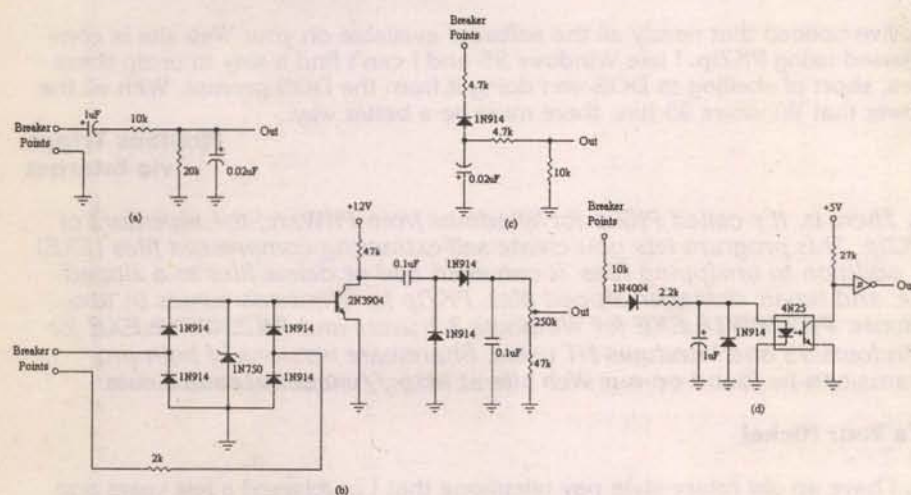
In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at TJBYSERS, on the Internet at TJBYSERS@aol.com or by snail mail at *Nuts & Volts Magazine*, 430 Princland Ct., Corona, CA 91719.

### A Tachy Question

**Q.** I read with interest your response to reader Sutherland regarding the use of a 556 to read a null from two ignition coils. My question is how do you condition the signal off the coils? Mr. Sutherland asked you not to include it in your solution, but please show the rest of us the signal conditioning circuit. Also, what is the purpose of the 1N4001 diode?

**Guy Haggard**  
via Internet

**A.** I assume the reason Mr. Sutherland didn't ask for a signal conditioner is because he knows that you have to tailor these filters to the task at hand. There is no "one size fits all." Here's a medley of signal conditioners suitable for use with breaker-point gas engines. BTW, the 1N4001 diode in my original design is used as a voltage clamp to prevent the input voltage from exceeding  $V_{cc}$ , which would destroy the IC. As you can see from the circuits below, diodes are commonly used in these filters.



### CD-ROMs And The Oldies (amplifier, that is)

**Q.** I have an old Sansui 5000 stereo receiver power amplifier in perfect shape. I want to connect one of the new CD changers to one of my input jacks. The Sony CD changer that I have in mind has a output specification of two volts at 50K. Unfortunately, the least-sensitive input jack I have is a very low 200 mV. Is there a circuit I can build or buy to match these parameters to my old amplifier? I'm including a schematic of my input stages.

**Monte Meyers**  
Bothell, WA

**A.** Yep, you've got an oldie, but a goodie. The problem is that, back in those days, we didn't have Walkmans or laser-powered CD players capable of delivering two-volt signals. Instead, the signals came from faint magnetic phono pickups or unamplified tape heads. I can remember my "prized" E80 phono cartridge churning out a whopping 3 mV! Now that we can pump out two volts, the signal-to-noise ratio and overall fidelity has improved considerably. After looking over your circuit, my suggestion is to completely bypass the preamp section and plug into one of the tape monitor channels (A or B). I have a Philips model 920 CD player that's plugged into a Dynakit preamp from the early 60s via the tape monitor port that works just fine. It, too, has 200 mV sensitivity. If you experience distortion because of signal overload, simply put a 150K resistor in series with the tip (hot lead) from your CD changer.

### Another Tachy Question

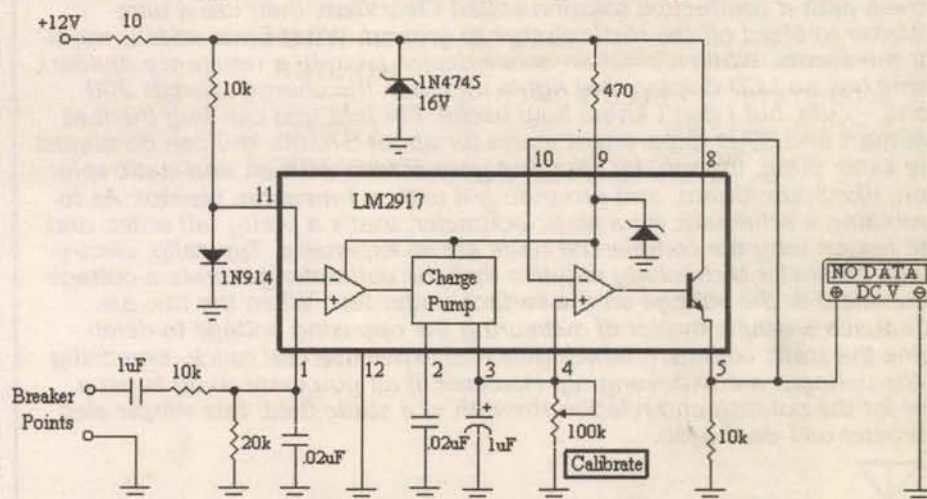
**Q.** I just discovered a goldmine in your column in *Nuts & Volts Magazine*! I'm not well-versed in electronics, but I do have an interest in trying things new. I've spent the majority of my 66 years as a power electrician, so I have a

fundamental knowledge of the craft. In the October issue, you presented a schematic for building an interface to facilitate using a digital VOM as a tachometer. I'd like to build this gadget, but I need more information, like:

- 1) What is the DC voltage required to operate the device?
- 2) How is it connected to the VOM?
- 3) If a 555 timer chip is used instead of the op amps, what is the connection scheme?
- 4) I wish to use the device to measure the RPM of both single cylinder and multi-cylinder gasoline engines. What do you suggest that I use to provide a signal input?

**Paul Tyson**  
Alpine, CA

**A.** While I have a soft spot for 555 designs, this project screams for National Semiconductor's LM2917 frequency-to-voltage converter. This chip is specifically designed for use in automotive tachometer applications, and requires few external parts. The circuit below shows a tachometer design for four-, six-, and eight-cylinder engines.



In this design, a protection circuit composed of a 10-ohm resistor and 16-volt zener diode protect against transients which are commonly found in automobiles. With the values indicated, the voltmeter will read six volts at 6,000 RPM. The approximate settings of the Calibrate control are 90K for four-cylinder, 75K for six-cylinder, and 20K for eight-cylinder.

### Three Quickies!

**Q.** Three quick questions:

- 1) If a phase-locked loop is used to "acquire" the reference color-burst frequency from the back porch of the horizontal blanking pulse (NTSC), what keeps the PLL from unlocking between bursts?
- 2) Would Craig's Deoxit be an effective solution to the oxidation associated with the "dry contact" effect of high-resistance relay contacts?
- 3) Where is the best place (including cyberspace) to learn everything I need to know about Geoworks?

**Joseph F. Richmond**  
Joppa, MD

**A.** Sorry, only one question per customer. Not really, but I have to keep the answers short. The answers are: locked by sync, maybe (probably not), and 617-661-0590. Okay, I'll fledge it out. 1) The PLL doesn't have to be locked with the signal 100% of the time. Once it acquires a signal it will maintain that frequency for as long as it can - or is forced to change by an outside influence, which is why it's the perfect decoder. 2) Never heard of the product, but if it's what I suspect, forget it for this application. 3) 617-661-0590.

### Modem Troubles

**Q.** My computer doesn't recognize my new Sportster 28.8 external modem. I'm upgrading from a Sportster 14.4 external modem, which my computer has no problem recognizing. I've made sure that the DIP switches are in the proper positions, and have run the Windows 95 install procedures as



described, but still nothing. My connections are working, as the use of the 14.4 proves, and the power switch is on. All my explorations have lead to a dead end. What next?

**Doug Scholes**  
Barrie, Ontario, Canada

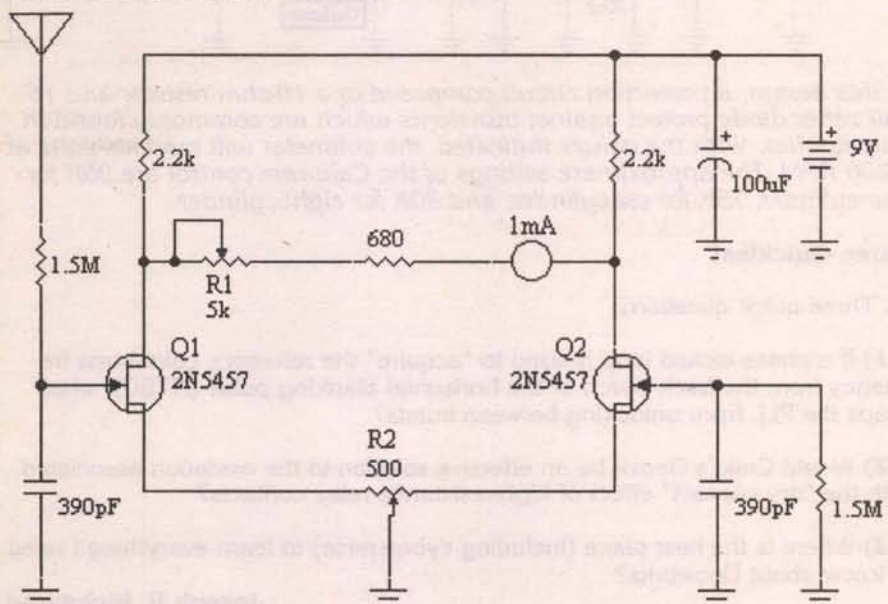
**A.** There's always the outside chance you have a bad modem or defective interface cable. The best way I've found to troubleshoot any internal or external modem problem is with a shareware program called the Modem Doctor. The Modem Doctor checks every serial port chip (UART) register, interface cables, modem register, and protocol command for proper handshaking signals. You're informed if the Doctor runs across something that isn't quite right. The Modem Doctor also lists the type of UART and modem you have installed, and can output a copy of the test results to your printer or a file. You can download this program from our Web site (<http://www.nutsvolts.com>) under the name **MODEMD60.ZIP**.

### Static Voltmeter

**Q.** Can you provide a schematic and parts list for a static voltmeter? The units on the market are too expensive for a novice experimenter to purchase. Also, is there a way to eliminate static build-up on my TV screen? Enclosed is an article which describes one such unit on the market that claims to banish screen static.

**R. Walthers**  
Las Vegas, NV

**A.** The product you sent to my attention is a device called "Ernie" from UltraStat (800-460-7828). The concept is quite simple: You spray the CRT's screen with a conductive solution called ClearView, then use a wire whisker to bleed off the static charge to ground. What Ernie does is monitor the events. While it's not an active device (simply a resistance divider), Ernie has an LCD display that lights up when the charge exceeds 300 volts — cute, but I don't know how useful. I'm told you can buy them at Walmart and other department stores for about \$70.00. You can do almost the same thing, though, by spraying your screen with an anti-static solution, like Static-Guard, and grounding it with a 1-megohm resistor. As to providing a schematic for a static voltmeter, that's a pretty tall order, and the reason why the commercial units are so expensive. Typically, electrostatic voltmeter technology requires that the voltmeter generate a voltage equivalent to the voltage on the surface under test. When the two are equal, it's a simple matter of measuring the opposing voltage to determine the static voltage — which gets real expensive real quick, especially if the voltages are wide-ranging. However, if all you want to do is get a feel for the polarity and relative strength of a static field, this simple electrometer will do the job.



At the heart of this electrostatic voltmeter are two JFET transistors connected in a balanced-bridge circuit. The gate of Q1 is connected to a sensor antenna, while Q2's gate is referenced to ground. Static charges sensed by the antenna cause the meter to deflect left or right, depending on the polarity. R2 is used to balance the bridge circuit, and R1 sets the meter's sensitivity, which is a general-purpose, 0-1mA movement.

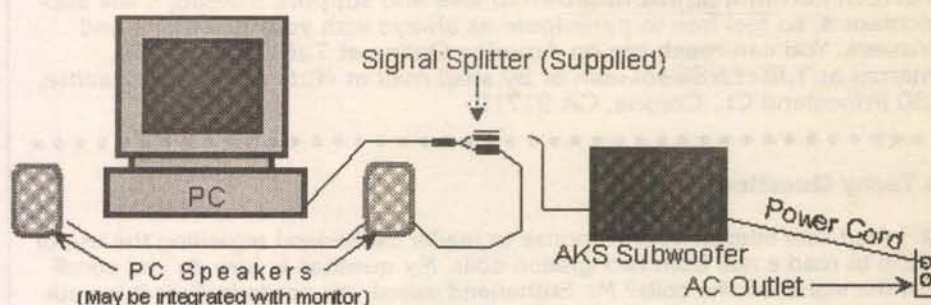
### Subwoofer Installation

**Q.** What is the proper way to add a subwoofer to an existing two-channel Sound Blaster-16 sound card? My existing powered speakers don't have a jack for a subwoofer, nor is there a jack on my subwoofer for the stereo speakers. Do you have a circuit that I can build for this purpose?

**Stanley Siu**  
Chino Hills, CA

**A.** I'm going to assume that you have a powered subwoofer, and not just

a speaker somebody told you was a subwoofer. The reason I bring this up is because subwoofers typically have very large cones, with a long stroke, that have to move large masses of air to reproduce the 30 Hz sounds that define a subwoofer sound. (Actually, subwoofer is defined as those frequencies between 20 Hz and 150 Hz.) This takes power — about 10 to 30 watts. As you point out, the Sound Blaster-16 has two audio channels, and you have only one subwoofer. Fortunately, the human ear is virtually unable to detect the origin of bass sounds, so having two subwoofers is of no benefit from the standpoint of stereo separation. To install the subwoofer you simply place it across the hot leads of the right and left channels using a stereo plug splitter from Radio Shack (part number 274-313), as shown in the drawing below.



The above drawing was provided by **AKS Acoustics of Wilton, NH (800-213-5119/603-654-5388)**. AKS is a major supplier of powered subwoofer speakers for use with the PC, and their Web site (<http://www.aksa.com/index.htm>) is a wealth of subwoofer information. If you decide to cobble your own amplified subwoofer, it can be done using a very large speaker (eight inches and bigger) driven by a Radio Shack bridge amplifier and electronic subwoofer crossover box (Radio Shack part number 12-1974). However, expect to pay as much or more as an already-built system from AKS or Yamaha.

### PKZip For Windows

**Q.** I've noticed that nearly all the software available on your Web site is compressed using PKZip. I use Windows 95 and I can't find a way to unzip these files, short of shelling to DOS and doing it from the DOS prompt. With all the power that Windows 95 has, there must be a better way.

**Mobious Trippe**  
via Internet

**A.** There is. It's called PKZip for Windows from PKWare, the inventors of PKZip. This program lets you create self-extracting compressed files (EXE) in addition to unzipping files. It can even add or delete files to a zipped file, and repair damaged zipped files. PKZip for Windows comes in two flavors: **PK250W16.EXE** for Windows 3.1 users and **PK250W32.EXE** for Windows 95 and Windows NT users. Shareware versions of both programs can be found on our Web site at <http://www.nutsvolts.com>

### It's Your Nickel

**Q.** I have an old rotary-style pay telephone that I purchased a few years ago from an electronics store, which, unfortunately, went out of business shortly after I bought it. Now for the real problem: I just moved to another state, and in the move, the receiver arm broke off. The arm is made of pot metal that is covered with heavy chrome. Would you have an idea of a business that sells parts for antique phones?

**Moses Mendzer**  
via America Online

**A.** There's a dynamite company in Portland, ME, called **Phone Source** (<http://www.biddeford.com/phonesrc/order.htm>; phone: 207-774-2828), which stocks parts for virtually every phone ever made. They'll also repair it. Unfortunately, they are pricey. The part you describe costs \$60.00; the minimum labor to install it is \$100.00. If you have access to "big-city" Yellow pages, you might be able to find a dealer with cheaper prices. Another thing you can do is cast a new part using the old part to make a mold. Check with your local hobby or crafts store for details.

### QuestLink Delivers Datasheets

**Q.** I've developed an interface to protect monitors in an industrial environment. For the keyboard, I use a membrane keyswitch and a programmable keyboard decoder from Hagstrom Ele. However, the cost of this arrangement is prohibitive. What I'd like to do is make my own keyswitch using the Intel 8042 controller. Where can I find the engineering notes on this chip? I've looked all over the Internet with no luck.

**John Kovach**  
via Internet

**A.** Have you tried QuestLink's site at <http://www.questlink.com/index.html>? They have data sheets for about ten 8042 keyboard controller chips from three different manufacturers, including Intel. In fact, this site



is a goldmine of data for the serious inventor or hobbyist. The data sheets are in Acrobat format (the Acrobat reader is free, and can be downloaded from this site, too), and are identical to the datasheets distributed by the vendor.

<http://www.questlink.com/products.qry?id=140500&title=Search+Results+for+Product>

Search Results for Products Like 8042		
Part #	Description	Org
<b>CHIPS and Technologies</b>		
N92N8042	CHIPS AT Keyboard Controller	
N93N8042A	CHIPS AT Keyboard Controller	
<b>Intel</b>		
8042	ROM Device for Desktop Keyboard	
80C42	ROM Device for Desktop Keyboard, Low-Power	
80C51SI	Keyboard Controller	
80L42	ROM Device for Keyboard, 3.3V	
81C51SI	Keyboard Controller	
8242	Phoenix Firmware Version 2.5 for Desktop Keyboard	

## MAILBAG

Dear Mr. Byers:

Your "Electronics Q & A" column in the January 1997 *Nuts & Volts* Magazine is exceptionally interesting. The answer about a sequence timer is something I've wanted for some time. However, the value of the capacitors identified as C1 are not given, nor are the values for the potentiometers marked as R1. Please let me know their typical values.

The second part of this message relates to the answer given for the DTMF decoder. The timing capacitor for the topmost decoder, the one for 1477 Hz, is shown as 0.1 uF, and the bottom two, 1209 Hz and 941 Hz, are shown as 1 uF. The explanatory text mentions 0.1 uF for all of them. Which value is correct, 0.1 uF or 1 uF?

**R. Keith Heinsohn**  
via Internet

Response:

I guess the solution kinda got buried at the bottom of the drawing, where you'll find the formula  $t = 1.1 \times R1 \times C1$ , where  $t$  is in seconds,  $R$  is in ohms, and  $C$  is in farads. This is the algorithm for calculating the values of  $R1$  and  $C1$ .  $R1$  should be in the range of 20K to 10M;  $C1$  can be any value that fits these parameters. For example, a one-minute timer would generally have the values of  $R1 = 545K$  and  $C1 = 100$  uF. Of course, these values never work in real life because of component tolerances, hence the potentiometer. As to your second question, oops! They're all 0.1 uF.

**TJ Byers**  
Q & A Editor

Dear Mr. Byers:

In response to your comments on no-ballast fluorescent lamps, I remember them. I bought one in '83 or '84. They were made by Lights of America and were heavily promoted in all of the hardware stores, costing \$9-\$12 (depending on whether the bulbs were included). I used mine daily for about nine months, then it died. I thought I could replace the ballast, so I opened it up and surprise, no ballast — just a capacitor with a low-wattage resistor across it. One capacitor per tube, and I forget if it was in parallel or series. The light was still under its one-year warranty when it died, so I took it back to the store and got a replacement. The replacement looked a little different, so I checked inside, and they had added a transformer or inductor for each tube. Apparently, the first design wasn't robust enough.

**Tom Harrison**  
via Internet

Response:

Thanks for your input. I placed a call to Lights of America (714-978-2905), but nobody remembers this product. However, I spoke with a technician who told me that several years ago they made a fixture with the ballast built into the lamp socket, where it was hidden from sight! This design used a 6 uF, 250-volt non-polarized capacitor. Could this be the answer?

**TJ Byers**  
Q & A Editor

Dear Mr. Byers:

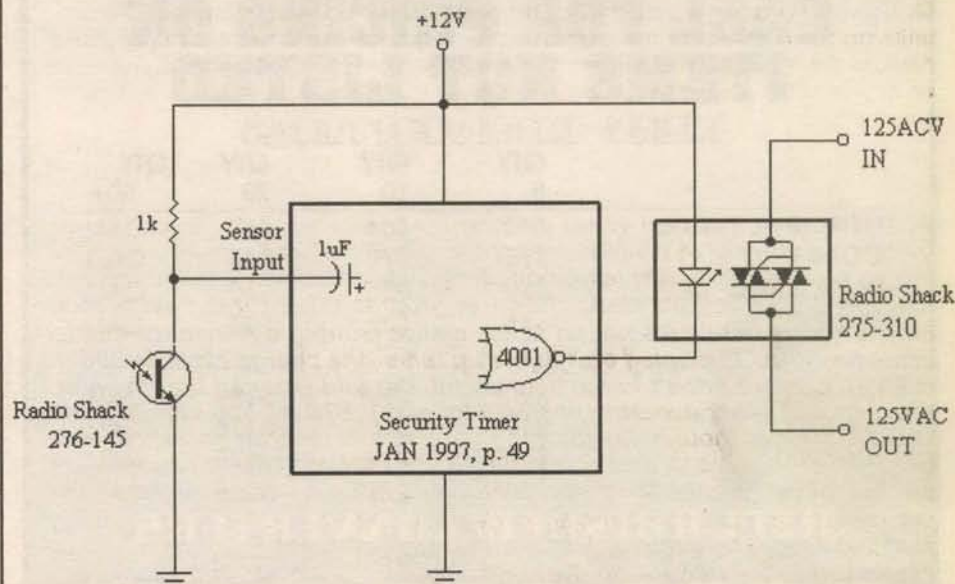
I have been looking for quite a long time for a circuit such as the one called "Security Alarm Unarmed" in the January issue. However, I need to have the ON time variable from 5 to 15 seconds, and about 30 to 60 seconds for the "cooling-off" time. I realize this is probably done with the capacitor values, but I'm fairly new to electronics and don't know how to go about it. Also, can I use my Lintronic ultrasonic motion detector (which I bought from Brigar) as both

a trigger and relay?

**Richard Gauger**  
via Microsoft Network

Response:

Actually, it's done using a variable resistor (potentiometer). Like Mr. Heinsohn's question above, you can use the formula  $t = 1.1 \times R1 \times C1$  to calculate the resistor and capacitor values. The values for 15 seconds are 270K and 50 uF; the five-second values are 91K and 50 uF. A 250K potentiometer in series with a 33K resistor will provide the range you're looking for. The one-minute values are 240K and 220 uF, whereas the 30-second values are 124K and 220 uF. Again, I'd use a 250K potentiometer in series with a 33K resistor. BTW, the 33K resistor serves as a current limiter to protect the 555. To trigger from your motion alarm I'd use a phototransistor monitoring the detector's Trip LED, but I wouldn't recommend using its power relay. I'd use an external solid-state relay, such as a Radio Shack 275-310, instead. Finally, change the Vcc voltage from 5 volts to 12 volts. Here's how to wire everything together.



**TJ Byers**  
Q & A Editor

## Reader's Tip

Like money and computer memory, you can never have enough Internet search engines. Here are four new engines that are worth looking into.

**Steve Bass**  
Pasadena, CA

**\*\*MetaSeek Giant 76 Engine MetaSearch**

<http://www.netseek.com/metaseek/>

**\*\*Inference**

<http://m5.inference.com/ifind/>

**\*\*HotBot**

<http://www.hotbot.com/>

**\*\*PriceWatch**

<http://www.pricewatch.com>



Like many of today's powerful search engines, MetaSearch taps into the resources of other Internet search engines, such as Lycos and Yahoo.



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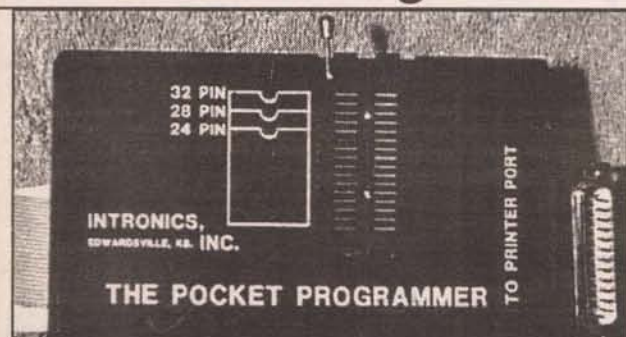
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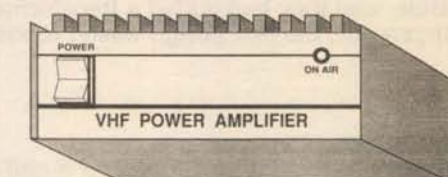
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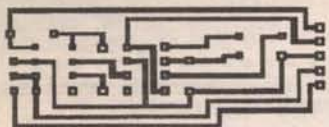
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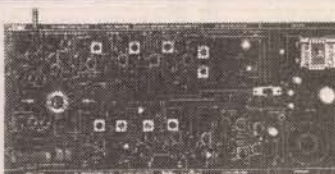
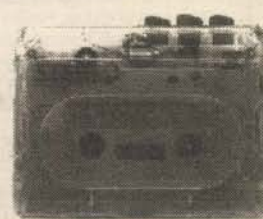
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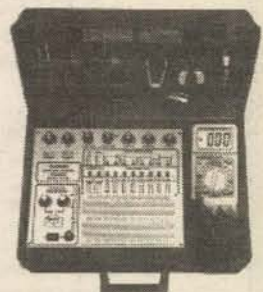
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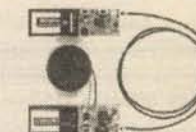


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2 year warranty on all parts  
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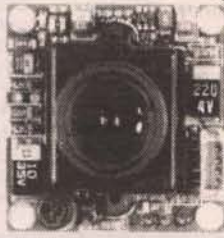
Prices subject to change without notice.



# Looking for Something?

## NEW MICRO CAMERA, w/audio

1/3" CCD, with 266K Pixels, 420 Lines Res., 0.3 Lux sens. AGC, Auto Shutter. Low Power 9VDC @100mA, Std. model has 3.7mm, 78° FOV lens, Pinhole model has 72° FOV. Both focus from 10mm to infinity. A real glass lens! WHY BUY DISCONTINUED OR SURPLUS? New first quality Standard NTSC video out. 1/2 once! IR SENSITIVE! Size Std. 1.2"sq. x 1" d. PH is .75" d, w both 1/8" leads attached.



GM-1000-STD.....\$99 GM-1000-PH.....\$99  
GM-1000STD/Audio.....\$119 GM-1000-PH/Audio.....\$119

## SEE IN TOTAL DARKNESS

NEW, High performance CCD micro camera suits many applications. The GM-164IR has a 92° FOV, provides 410 Lines resolution with 0.1Lux sens. AGC and Electronic shutter. Low power 12VDC @ 225mA operation, with 6 IR LED's illuminated. The invisible 780nm, Infrared LED's allow observation in total darkness up to 20 feet. Perfect for garage, front door, or dark hallway. Size: 1.75" square. X 1" thick. Both cameras utilize SONY CCD and video chipset. First quality throughout.



GM-164IR.....\$119ea., ABS enclosure, 2' x 3' x .9".....\$14.95

## Mini, Super Sensitive, C-mount.

GM-410, B&W, Size only 38mm SQ. x 40mmD, 1/3" CCD, >270,000 Pixels, 410 Lines Res., Sens. 0.05 LUX., AGC & Electronic shutter. 12V @110mA power. Three lens options exploit its superior performance.

NTSC out, IR SENSITIVE, RCA video connector, std. DC pwr. jack. True performance not hype! This camera will out-perform ANY camera in this magazine guaranteed! NEW! w/o lens.....\$169

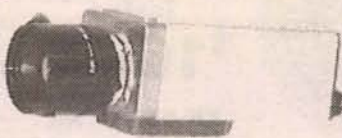
w/16mm, f1.6, (15° FOV).....\$199, w/8mm, f1.3, (30° FOV).....\$219  
w/4mm, f1.4, (56° FOV).....\$219, w/4mm, f1.4 Auto Iris Lens.....\$305

## 1/2" COLOR CCD CAMERA,

### New JVC TK-885U,

### Industrial Quality, 330 Lines, Auto Iris Lens

Rugged aluminum housing. Standard C or CS mount. Back focus adjustment. Removable 1/4-20 mounting plate. NTSC video on BNC jack. Four pin auto iris jack. DC power screw terminal strip. (What could be easier?) External AGC on/off, Adjustable white balance and normal or fast 1/1200 shutter speed. Finally add the CANON 6mm, f1.2 Auto Iris lens. A perfect, no nonsense, color surveillance system. Camera and lens for less than the price of the camera alone! You can't touch this anywhere for less. Perfect for installers. Ltd. Qty.



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Camera less lens.....\$179

Canon 6mm, f1.2 A/I Lens only.....\$69

## WORLDS SMALLEST VIDEO TRANSMITTER,

The TVX-100 is only an incredible 1.15" x 0.8" x 0.4" in size, but transmit crystal controlled hi-res. images with it's 100mW output! This is the transmitter you have been waiting for.

Module shown next to watch for size. Smaller than the 9V battery which powers it.

Requires only 35mA for operation. Factory tuned ready for you to receive on cable channel 59. Will work with color or B&W camera. We provide all accessories: UHF Bow tie antenna with balun and 3' F cable and adapter for TV. Team with our GM1000 PH camera for a system that fits in a cigarette pack!

TVX-100 w/accys.....\$199.

TVX-100 w/GM-1000 Pinhole Camera.....\$299.

## INFRARED, 3MW, LASER DIODE MODULE,

New, Toshiba LT-026MD, 5mW, 780nm IR laser diode mounted in a super rugged aluminum thermal base. An adjustable glass collimating lens and sophisticated laser power supply complete this impressive industrial module. Size: 2.375"W x 1.5"H x 1.6"D with 3.4" Adjustable output via trimpot.

Special \$29ea. or 3 for \$69.

## BEAUTIFUL TRANSIT CASE, from ZERO

Deep drawn aircraft aluminum. Black powder coat finish. Lustrous dual chrome latches and custom resettable combination lock. Black, fold down handle. Foam interior easily removed or cut.

Originally intended to hold glass plates. Very good to new condition. Overall size: 16"L x 9"W x 15"D, Inside: 9.5 to 14"L x 7.5"W x 12"D Like New. Super quality.

Limited quantity. Reg. price..\$150 NOW....\$59ea.

## SEE in TOTAL DARKNESS! IR FLOOD

168 LED's !! Powerful, not power hungry. Projects up to 20 meters. 24V wall adapter, incl. Size only 4.5"Wx6.6"Hx1.5"D

Commercially made NEW!

IR FLOOD.....\$159ea.

W/Internal Camera...\$369ea.

## WEATHER RESISTANT

### Camera Enclosure

Solid extruded aircraft aluminum. Size: 3.5"W x 3.7"H x 14"L, Glass window. New.....\$69ea.



## EVERYBODY WANTS "THE GREEN"

Now you can have it all.

3mW ARGON LASER. Super brilliant turquoise beam looks as bright as a 20mW HeNe! New, Uniphase Model 2202-3 with power supply.

The 488nm, TEMoo mode is something to see! The power is in the wavelength. This highly visible beam operates where the eye is most sensitive. Very impressive for it's size. Head only 2.5" diam, and 13" long. Plug and play operation. Standard 110VAC operation. Compact power supply and fan cooled head. Less than 1/4 the price of a new one. Photo not available at press time. Looks like a scaled down version of the 2213 below.

Limited quantity. Our price.....\$695ea.

75mW ARGON LASER. Brilliant Turquoise beam, Uniphase Model 2213-75 w/2113 power supply.

The 488nm, TEMoo mode is something to see! Power for a "serious" display. Excellent plug and play condition. Power supply can be controlled remotely with optional interfaces. Standard 220VAC operation. Compact power supply and fan cooled head. Less than half the price of a new one. Reg. \$5890, Our price.....\$1995

Basic remote.....\$175, Remote w/LCD display.....\$595



## FRONT SURFACE MIRROR with ADJ. MOUNT,

19mm diam. mirror, attached to a sturdy adj. mount, integral riser & base machined from a single aluminum block. Dual allen adj. screws. Optical center 46mm high. Black anodized. Overall size: W50mm x 62mmH x D26mm. Removed from system. Ltd. qty.

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## LINEAR SLIDE, NEAT Model SC300, Anodized aluminum,

industrial quality. Ball bearing. 50lb. cap. Like new, some have a scratch on the edge where a dummy used a utility knife to open the boxes. Size: 1.75"Wx4"Lx.75"H with 3.4" travel. Use two for x-y. Ltd Qty.

Reg.\$86ea.

Special \$34 or 3/\$85

## CLAMP-ON CURRENT PROBE, AEMC model

100.101, operates with any DVM. The 1000:1 ratio provides measurements up to 1000Amps with 1% accuracy! Frequency range 50 to 5000Hz. This is an industrial quality current transformer rated for use on cables up to 2000V. Two inch diameter opening for cable. Overall size 8"L. Banana jacks for output. Brand new. Special.....\$49ea.

## FIVE OUTPUT POWER SUPPLY

Will power just about anything you can dream up. New, Elpac Model 1822 fully enclosed in an attractive brushed steel and black enclosure.

Industrial quality power supply with five individually fused outputs as per table below:  
+5VDC @ 2.5Amps  
±12VDC @ 0.5Amps  
±20VDC @ 2.5Amps Trimmer externally adjusts from ±15 to ±24VDC

Operates from 110VAC or 220VAC. Size: 6"H x 8"W x 16"D. A fantastic deal \$24.95ea. or 3 for \$59.00



## LASER SIGHTS, 650nm and 635nm

### Rugged and dependable.

Windage and Elevation are easily adjustable using internal adj. screws. Custom mount, alkaline battery and remote switch included. Simply specify your make and model.

LASER SIGHT, Super 650nm.....\$69

LASER SIGHT, Ultra 635nm.....\$109



## MITUTOYO

### DIAL INDICATOR with 0.01mm resolution and 10mm stroke

New, Model # 2046-11 indicator. Individually boxed with certificate of calibration. A beautiful instrument with a 2" diameter face with high contrast yellow background. Fits all standard holders.

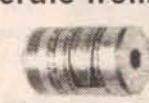
Mitutoyo Indicator.....\$49



## NEW! Now operate from 4.5 to 12VDC !

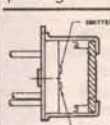
### SPECIFICATIONS:

DC Power: 3 - 6Vdc, @65mA  
Power out: 4.5mw max.  
Range: 100-800 Meters  
Glass Collimator  
Size: 0.41" diam x 0.71"



Shown Actual Size

the best value quality available for commercially made, Subminiature, laser modules. A glass collimating lens provides 1.5mRad performance. (divergence comparable to HeNe lasers.) Wide input range, internal surface mount, 4.5 to 12VDC power supply. Machined brass package for excellent thermal characteristics. Truly a quality laser module.



IR LASER DIODE, 5mW, SHARP LD022MD, Brand new! Very popular 5mw, 780nm laser diode. Excellent choice for laser communications, alarm systems, covert illuminators and target designation. Highly visible to CCD cameras. These must be protected from excess current and static electricity. Individually tested prior to packaging. \$7.95ea. or 3/\$20

## Our Exclusive "LAB STYLE" LASERS, 650nm and 635nm, Rugged and Dependable. One Year warranty.

Adjustable X and Y beam position. Aircraft aluminum housing. Internal battery and on-off switch included. Makes a super pointer. Size: .75d x 2.75"L

LAB LASER 650nm.....\$79

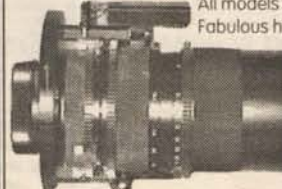
LAB LASER 635nm.....\$109



## MOTORIZED ZOOM LENSES,

### Models with auto iris as well.

All models are new or like new. Fabulous hi-res. optics with standard C-Mount. Superior Fujinon, Vicon and Computar lenses like these normally cost from \$400 to \$1500. Now you can afford the best. There is no



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### Type Focal Length A/I Price

A: 18 to 144mm, 8X, f2.0 YES \$299  
B: 11 to 110mm, 10X, f1.8 NO \$299  
C: 11 to 110mm, 10X, f1.8 YES \$399  
D: 12.5 to 75mm, 6X, f1.2 NO \$149  
E: 8.5 to 51mm, 6X, f1.2 NO \$199

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A low power collimator pen containing a MOVPE grown gain GaAlAs laser diode. Pen delivers 2.5mW @ 820nm. Operating voltage of 2.2-2.5V @ 90-150mA is designed for lower power applications. Measures 11 mm x 27 mm.

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20MHZ

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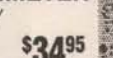


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WITH CAP/FREQUENCY/

TRANSISTOR TESTER

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**\$34.95**

### PRECISION FUNCTION GEN.

5 MHZ W/ DIG. DISPLAY

MODEL 4011

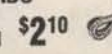
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SET OF 10

Part No. E05ALS1



**\$2.10**

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SWITCHABLE X1, X10

Part No. E05SPAK220

**\$12.95**

### SWITCHES

8 POS DIP ..... 60¢ ea.

Toggle Mini SPDT .... 50¢ ea.



### COMPONENTS

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LM741 10 Min. .... 27¢ ea.

74LS00 10 Min. .... 18¢ ea.

7805 Regulator 10 Min. .... 30¢ ea.

2N3904 10 Min. .... 6¢ ea.

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February 1997 101



## New Products

are individually addressable. It can be used to store data from data loggers, to store variables, arrays, or as a serial data buffer. The cost is \$24.95.

The **Mini-Watt** is the ideal power supply for five-volt systems. Using two low-cost NiCads and a step-up regulator, the Mini-Watt can act as a low-cost battery powered supply. It can also provide five volts at 200 mA. Cost is \$29.95.

The **Motor Mind** controls up to 30-volt motors with peak currents of 3.5 amps. It operates using serial communication at 2400 baud to allow digital systems to directly control DC motors. The Motor Mind also acts as a buffer between your system and noise generated by the motor. Cost is \$29.95.

The **Pocket Watch** allows you to set the time, and then read it back whenever you desire. Read seconds, minutes, hours, day of the month, and year. Leap-year compensation is built in.

An alarm function is also designed into the Pocket Watch. Set the alarm, and when the time comes, it sets a digital output to five volts which can be used to drive other electronic circuits. Cost is \$19.95.

All of these products can be used with BASIC Stamp designs.

For more information, contact:

**SOLUTIONS CUBED**  
3029 ESPLANADE STE. F  
DEPT. NV  
CHICO, CA 95973  
916-891-8045  
[www.solutions-cubed.com](http://www.solutions-cubed.com)

### STATIC RAM MODULES



**A**ccutek Thin SRAM Modules are offered in four configurations: 128K x 32, 256K x 32, 512K x 8, and 1 meg x 8 in SIP, SIM, and ZIP modules.

Available in low standby power versions with a range of access times from 55 to 100 nSEC and standard power designs as fast as

15 nSEC, Accutek Thin SRAM Modules operate for 5 VDC and have common I/O, chip enable, output enable, and write enable functions. Typical applications include VMEbus designs with tight spacing.

For more information, contact:

**ACCUTEK MICROCIRCUIT CORP.**  
2 NEW PASTURE RD., STE. 1  
DEPARTMENT NV  
NEWBURYPORT, MA 01950-4054  
508-465-6200 FAX: 508-462-3396  
1-800-652-7505

### DIGITAL CONTROLLER



**M**alcom's Leister KSR Digital Controller and thermocouple probe measures and controls the temperature of all Leister hot air blowers and heat sources to  $\pm 1^\circ\text{F}$ . Featuring a front panel LED display with the process temperature and keys for setting process values, this programmable controller provides automatic tuning with alarm and heater burnout safety indicators.

For more information, contact:

**THE MALCOM COMPANY**  
25 ABBOT ST., DEPT. NV  
ANDOVER, MA 01801  
1-800-289-7505 FAX: 508-475-7242  
<http://www.malcom.com>  
E-MAIL: [malcom@aqua.net](mailto:malcom@aqua.net)

### IMAGEGUARD II CRT MONITOR ENCLOSURE



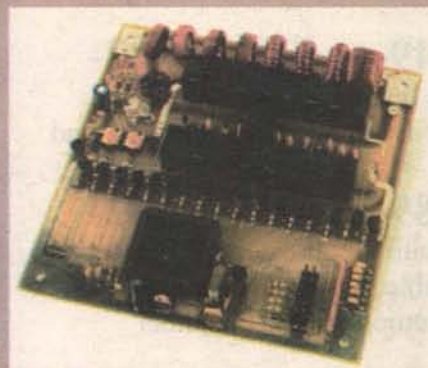
**M**agnetic Shield Corp. announces a new product that eliminates monitor screen disturbances due to magnetic fields from power lines, medical equipment, machinery, or even another computer. ImageGuard II CRT monitor enclosures surround the display to prevent smeared colors or jitter in the screen image. Shield construction utilizes CO-NETIC AA magnetic

shielding alloy to provide high attenuation of magnetic fields, restoring proper monitor operation.

For further information, contact:

**MAGNETIC SHIELD CORP.**  
740 N. THOMAS DR., DEPT. NV  
BENSENVILLE, IL 60106  
630-766-7800 FAX: 630-766-2813

### QRP TUNER KIT



**L**DG Electronics announces the introduction of their QRP automatic antenna tuner kit. The tuner is a high-efficiency, microprocessor-controlled, switched "L" network designed to work with dipoles, verticals, inverted vees, beams, or any coax fed antenna in the 1.8-30 MHz range.

The QRP tuner kit retails for \$100.00 plus \$6.00 shipping in the US.

For additional information, contact:

**LDG ELECTRONICS**  
1445 PARRAN RD., DEPT. NV  
ST. LEONARD, MD 20685  
410-586-2177 FAX: 410-586-8475  
E-MAIL: [ldg@radix.net](mailto:ldg@radix.net)  
WEB: <http://www.radix.net/~ldg>

### LCD FLEX CIRCUIT



**A** new line of lightweight, low-profile LCD circuit modules offered in a variety of standard sizes and LCD arrays with flexible circuitry for a wide range of product design applications is being introduced by Vikay America, Inc.

Easily integrated into a wide range of industrial and consumer

electronic products, Vikay LCD Flex Circuit Modules can be supplied in standard LCD arrays, including 2 x 12, 2 x 12 with icons, 2 x 16, 2 x 16 with icons, and 4 x 12. Custom displays can also be provided.

**VIKAY AMERICA, INC.**  
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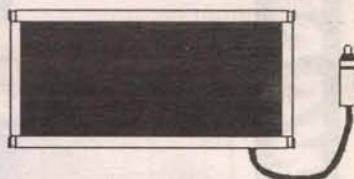


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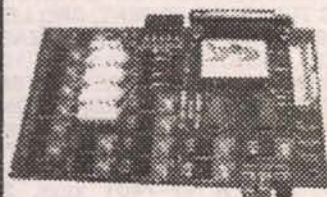
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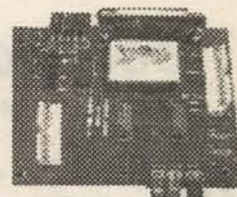
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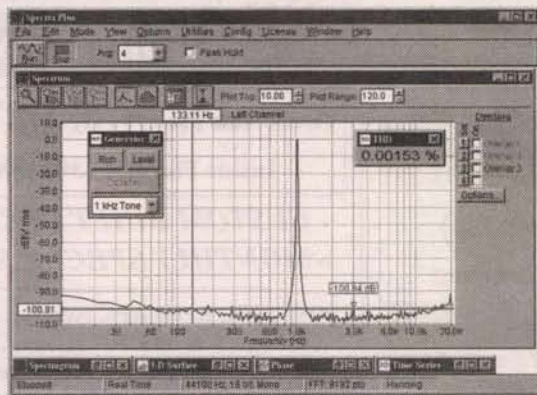
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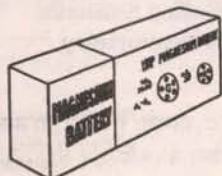
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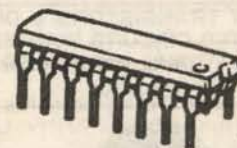
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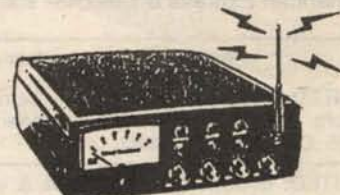
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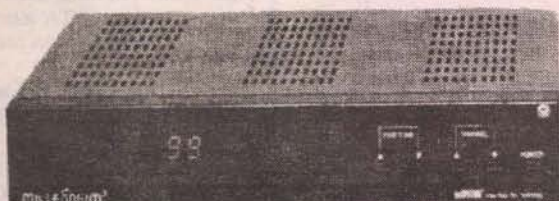
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by  
**Harry Helms**

indicates the number and arrangement of pixels on the display. For example, a 640 x 480 display means there are 640 pixels horizontally across the display and 480 pixels in each vertical line of the display. The more pixels in the display, the higher

**I**mages are showing up in all types of software these days. Web pages and multimedia CD-ROMs are loaded with images, and even plain vanilla Windows applications are using more graphics, icons, screen captures, and other images. If you're developing any kind of software, you need

# Software Wizardry

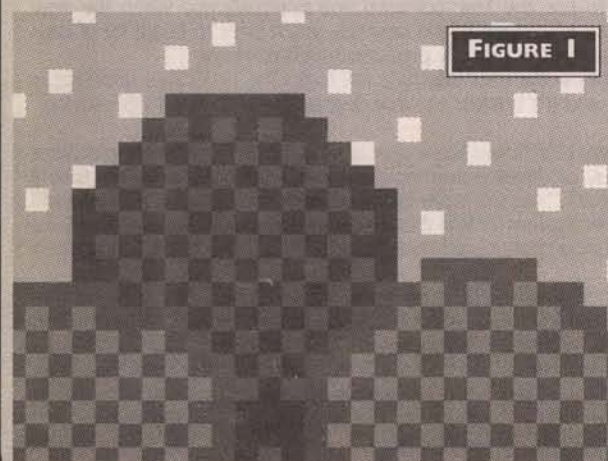
to understand image files. But using image files can produce rude surprises no matter how skilled you are in a programming language or development tool, such as major changes in color tones or resolution when imported into a project file. And if you're using images in a Web page, you have to contend with the large size of many image files and the lengthy time required to download them from the server.

To successfully use image files in Windows software, you have to understand how images are displayed on PCs, the different formats for image files, how colors are determined in images, and how images are compressed. In other words, you need to understand the topics we're going to discuss in this month's column.

## What's in an Image?

The video displayed on a PC monitor is significantly different from the video displayed on a consumer television set. If you haven't done so recently, take a close look at an image using a graphics program with a "zoom in" feature (like the Paint program supplied with Windows) or by looking at the image on a PC monitor using a magnifying glass. A couple of minutes spent examining an image this way will help you better understand the following paragraphs. Figure 1 shows what you might see.

If you did closely examine an image, you noticed that the image is composed of numerous discrete "picture elements," or pixels. Each pixel is independent of other pixels, and has its own color and intensity values. When viewed at a normal distance without any aid (like a magnifying glass), the pixels in an image cannot be distinguished from each other and "blend" together into a continuous image. The resolution specified for a display



**FIGURE 1**

the image quality and the larger the size of the image file.

You're probably aware that many Windows PCs can display images having over 16 million different colors. Incredibly, all of those colors are created using various combinations of just red, green, and blue. The color of each pixel depends upon the values for red, green, and blue assigned to that pixel. The values for red, green, and blue are indicated by a value from 0 (no trace of the color whatsoever) to 255 (the color is at maximum intensity, or "fully saturated"). If a pixel has a value of 0 for each color (0,0,0), this means the pixel has a complete absence of color and will therefore appear black. By contrast, a pixel with a value of (255,255,255) has each color at maximum intensity and would appear white. A pixel with a value of (128,128,128) would appear gray. Other combinations include cyan (0,255,255), magenta (255,0,255), and yellow (255,255,0).

## Making a Good Image With PCs

The values for red, green, and blue are usually represented in hexadecimal notation. Hexadecimal is a base-16 numbering system using the digits 0 to 9 and the letters A through F to represent the decimal values of 10 to 15. In "hex," the decimal value of 255 would be represented as FF. Many Windows development systems, like Visual Basic, use hex representation of pixel colors.

If a range of 0 to 255 (or 0 to FF in hex) is used to represent possible values of red, green, and blue, the total number of possible colors is equal to  $256 \times 256 \times 256$ , or 16,777,216 different colors. This is referred to in Windows as True Color. However, displaying that many colors requires additional memory and hardware. Since not all PCs can display True Color images, "256-color" video has emerged as the baseline for PC images. Any of the over 16 million colors can be included in the 256 colors displayed. The set of 256 colors displayed in an image is known as the image's "palette." Many graphics programs, development tools, and applications software allow users to select which colors are included in the 256-color palette for images created or displayed in that software. Figure 2 shows the Windows95 selection window that allows users to control how many different colors will be displayed by their PC monitor.

The number of colors used in an image is directly related to the size of its file. A True Color image will generally occupy over three times as much memory as the same image represented in the 256-color format. While this is generally not a concern with applications residing on a hard drive or CD-ROM, it can be a problem with applications on a floppy or Web pages. In particular, Web page images should be restricted to 256 colors.

## Bitmap and Vector Images

Most of the images you'll deal with on a PC will be

bitmap images. A bitmap image is what its name implies, namely a "map" of the pixels that form the image. The pattern of pixels forming a bitmap image is scanned from top to bottom in a raster pattern. For this reason, bitmap images are sometimes referred to as raster images. You can think of each pixel as one of the dabs of paint applied to canvas by an artist to make a painting. The pixel pattern in a bitmap image is difficult to alter or resize, and this means bitmap images tend to be "static." The standard Windows Paint program produces bitmap image files. A file for a bitmap image specifies which pixels on a PC monitor will be used to form an image and the color values of those pixels. File names for bitmap images end with such extensions as .BMP and .GIF.

Vector images use mathematical routines to generate vectors that define an image on a PC monitor. There is no fixed "map" of pixels describing their location or color values; those aspects are determined by the mathematical routines producing the vectors. The image vectors can be redefined mathematically, meaning vector images are easy to resize and alter. Images that you can "stretch" or "compress" by clicking on sizing "handles" and dragging them are vector images. Adobe Illustrator and Corel Draw are examples of illustration software that produce vector images. The resolution of a vector image depends on the resolution of the display device; a vector image will appear sharper on a 600 dpi laser printer than on a 300 dpi printer. Vector files are significantly smaller than bitmap files describing the same image.

## Palette Problems

Palettes are a VERY common source of problems when working with images. If I encounter an image that has incorrect colors or other problems, the first place I look is the palette used to create the image.

Here's a typical (and common) situation. Let's suppose a graphics artist prepares a 256-color image using a graphics program that allows development of a custom color palette for each image. The artist creates a custom palette for the image. When you get the image file from the graphics artist, you import it into a development tool or applications program that uses a different color palette. What happens when you try to open the image file?

The result is what is known as a palette conflict. When the palette of your development tool or applications program encounters a color in the image's palette that it doesn't have, it will attempt to substitute the closest available color in its palette. This means the image could look substantially different, depending on how many colors must be "approximated" and how extensively the substituted colors are used in the image (such as on a background). If the two palettes are highly different, it may be impossible to approximate all colors. In this case, pixels of various colors are used to substitute for certain colors. This is known as "dithering." The result is a grainy, fuzzy looking image. Figure 3 shows an example of dithering; the grainy, "broken" look of the image is due to a palette conflict between applications.

Dithering gets worse if multiple images with different palettes are used on the same screen display or Web page. This situation overtaxes the ability of your palette to make adequate color approximations. The dithering process could degenerate to the point where the substitute dots are random colors or even black.

Another source of dithering is when an image is created in True Color and then saved in 256-color format. When this happens, the graphics program has to approximate some colors and substitute for others.

The key to avoid palette conflicts and dithering problems is to be aware of the potential for them. Unless you know in advance that all PCs that will use the image can handle True Color images, develop all images using the default Windows 256-color palette. Don't develop in True Color and then save as a 256-color image, and don't use custom 256-color palettes!

## Hardware Issues

Not all image problems are software ones. Hardware variations – especially between the developer's PC and



# Software Wizardry

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FIGURE 2



the user's PC — can have a big impact on image quality.

Monitor resolution is a frequently overlooked problem area. One measure of a monitor's quality is "pitch." This refers to the spacing between the red, green, and blue phosphor dots that make up each pixel. Pitch is measured in millimeters, such as 29 mm. The lower the pitch value, the better the resolution of the monitor. Another big consideration is whether a monitor is interlaced or non-interlaced. An interlaced monitor first scans all odd-numbered lines on the screen, and then returns to scan all even-numbered lines. A non-interlaced monitor scans each line from top to bottom, producing a sharper image and less flickering.

Monitors also differ in the number of pixels per inch (ppi) they display. The typical PC monitor displays 96 ppi, while most Macintosh systems use 72 ppi monitors. If you create an image on a Windows PC and then import it into a Mac environment (or vice-versa), the image will likely look a bit different.

The amount of video RAM (VRAM) on a PC's video card is another big factor in image quality. The more

VRAM, the better! This is especially true if you're using True Color, since a limited amount of VRAM could mean your PC could run out of memory to display millions of possible colors. When a PC exhausts its available VRAM, the resulting image is dithered in a manner similar to a palette conflict.

If you're a developer, you probably have a PC with a high-quality monitor and plenty of VRAM. However, not all of your users will be so fortunate. That's why an inexpensive PC with limited VRAM and a interlaced, high-pitch monitor is a useful tool for testing image-intensive software.

## Compression and Decompression

Since image files are often so large, they can eat up a lot of disk space and take a long time to download from a Web site. To handle such problems, various image compression and decompression methods have been developed.

One common method is known as run-length encoding (RLE). RLE is based upon the fact that most pixels in an image are found in patterns having the same color. For example, an image may have several consecutive rows of blue pixels used to form a blue sky on an image. To RLE compress such an image, we could simply specify the color value of the blue pixel, where the color value first appears in a row, and how many consecutive times it is repeated in the row. When the image is decompressed, the algorithm uses the color value, starting position of the value, and consecutive pixels per row data to reproduce the image in its original form. For this reason, RLE compression is often called "lossless" compression because no degradation of the image occurs during compression or decompression. A popular image file format that supports RLE compression is the .GIF (graphics interchange format) format, which is often used for images sent over the Web. It supports 256-color images and typically gives 3:1 compression (in other words, the compressed image file size is one-third that of the file size for the equivalent uncompressed image).

While the compression offered by RLE is often useful, some images can occupy megabytes of space even after RLE compression. The solution is to use JPEG (joint photographic experts group) compression,

which can achieve typical compression ratios of 10:1 and sometimes even as high as 50:1. You might suspect there's a catch in getting such dramatically higher compression ratios, and you're right if you do: some of the "information" in the image is thrown away and lost during JPEG compression. For this reason, JPEG is known as "lossy" compression. When decompressed, a JPEG image will be degraded compared to the original. The more degradation you can tolerate, the higher the compression ratio you can achieve with JPEG.

When I was in school, I would sometimes take notes by dropping vowels from words as a form of shorthand. Here is a "uncompressed" sentence and a "compressed" version of it:

How well can you understand what I have written here?

Hw well can u undrstnd wht I hv writtn hr?

JPEG works in a similar way, by dropping pixels not essential for "understanding" the image. When decompressing, the JPEG algorithm "fills in" the missing pixels, much like you filled in the missing characters in the "compressed" sentence above. However, as more image data is discarded during compression, the more often the decompression algorithm will be unable to properly fill in the missing pixels and the lower the quality of the resulting image. The effect is very similar to dithering due to palette conflicts. JPEG can support True Color images, although their quality is often negated by the compression process.

While JPEG compressed images can be transmitted over the Web more rapidly because of their smaller size, the images require more time to decompress because of the complexity of the JPEG algorithm. Despite this, JPEG images are preferred for use on Web pages for larger images or those with rich, diverse color.

The intelligent use of images can add a lot to any software. I hope this month's column helps you avoid a lot of the problems I've had in my development efforts! NV

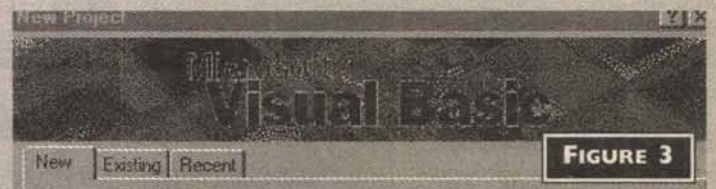


FIGURE 3

## The Prodigal Son Returns to Apple . . . But Did He Return Too Late?

My last column had a sidebar about the discussions between Apple and Be, Inc., over the possibility of Apple acquiring Be or licensing their operating system. As that issue of *Nuts & Volts* was going to press, Apple dropped a bombshell by announcing they were paying \$400 million to acquire NeXT, the software company founded by Steve Jobs, and that Jobs would be returning to Apple as a consultant on the development of a replacement for Apple's current operating system.

The Be operating system — currently running on the BeBox and on some Mac clones from Power Computing — currently offers features like true multitasking, protected memory, and advanced file system management that System 7 does not. Negotiations between Be and Apple broke down when Be's president, former Apple executive Jean-Louis Gassée, asked for too much money. NeXT had been unsuccessful in its attempts to do an initial public offering (IPO) of its stock in 1996, and started looking to be acquired by another company. Once the initial discussions started between Apple and NeXT, a deal was quickly struck, leaving Be out in the cold.

The NeXTStep operating system (OS) was introduced in 1988 to run on the since-abandoned NeXT computer. NeXTStep offers pre-emptive multitasking, multithreading, and multiprocessing. (The latter — the ability to use two or more microprocessors simultaneously and divide the processing workload among them — was one of the most impressive features of the Be operating system. It is a capability not available in Windows.) NeXTStep is object-oriented, and software development is supported by a rich library of objects known as NeXTObjects.

Steve Jobs won't be returning to Apple on a full-time basis or taking an active role in porting NeXT software to the Mac. Instead, he will be directly advising Apple president Gil Amelio and helping promote Apple (as he did in a joint appearance with Amelio at this January's MacWorld). Beta copies of the new merged NeXT/Mac OS are supposed to be available for shipment to test sites during the last quarter of 1997.

While only time will tell if the acquisition of NeXT will be Apple's salvation, I have a feeling that it's not.

I have to admit to being a fan of Be and the Be OS (but I have no financial interest in Be or personal relationship with any of its employees). I think Apple would have been better off to have acquired Be or licensed their technology.

One big reason is the time frame. The Be OS is already shipping on Mac clones. The

merged NeXT/Apple OS isn't scheduled for beta until the end of this year — and Apple's history of meeting target dates for the since-abandoned System 8/Copland OS doesn't give much reason for optimism. I'll be very surprised if Apple has its promised beta OS available before the end of this year.

The Be operating system would have given Apple's customers and software developers a state-of-the-art operating system NOW. By going the NeXT route, Apple is making them wait another year — or given them another reason to move to Windows.

NeXTStep is an operating system that is nine years old. When first introduced, it was years ahead of its time. Now it doesn't have many advantages over Windows NT. By the time the first new Macs with the NeXT/Mac OS are shipping, it may not have any real advantages over revised versions of NT. Adding new features will add more time to the delivery schedule.

Even more critical is that the first versions of the NeXT/Mac OS will not have backward compatibility with System 7 applications.

Apple executives speak in terms of having backward compatibility with existing System 7 applications or an emulator "someday." And, in truth, a major break with the past will be necessary to take full advantage of the PowerPC processor and other hardware. But the fact remains that you won't be able to use the Mac software you currently use when the new NeXT/Mac OS finally ships. To take advantage of the new OS, you'll have to buy a lot of new software — and hope that developers have actually produced such software.

There are also questions about how the user interface will look. The NeXTStep interface is different from the Mac interface, and it's unclear to what degree the combined OS interface will look like either.

Taking all of these items together, 1997 looks like a year of great uncertainty for Apple users and software developers. Why buy or develop any more System 7 applications when they'll soon be obsolete? Will the new NeXT/Mac OS really be available at the end of 1997, and will it be a significant improvement over System 7? Will there be enough software available to take full advantage of it? A lot of this uncertainty could have been avoided if the Be OS had been selected by Apple.

While many Mac users like to believe that Microsoft is evil incarnate, the gang in Redmond may turn out to be Apple's best hope for a successful transition to the new OS. Microsoft has announced that it will work closely with Apple as it develops its new OS, and also increase its investment in developing Mac applications. It is also porting some elements of Windows technology to the Mac, such as by enabling ActiveX controls to work in the Mac's OpenDoc containers. If Microsoft believes strongly enough in the new NeXT/Apple OS, that may be just the vote of confidence other software developers need.



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# The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project

## PART 1

by Steve Bender

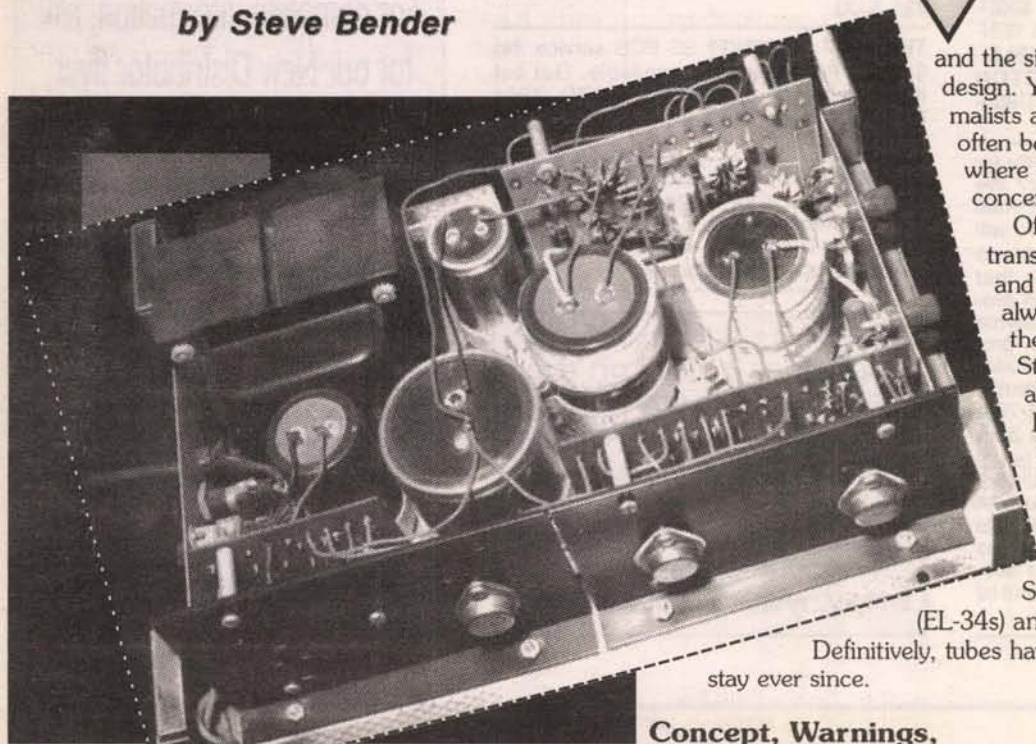


Photo 1: Original Transistor Dynaco Stereo-120

### My Tube Background

In my early youth, my first "stereo" was a record player with swing-out speakers of the four-inch kind. I had saved up all of \$39.95 to buy it and, a year later at its demise, I discovered a one-tube-per-channel amplifier augmenting its crystal cartridge.

My next early-on initiation to tubes, in the early to mid 60s, was tinkering inside a "live" Norelco Continental 300 Stereo tube-type tape recorder. Holding the heavy metal chassis in one hand and a metal screw driver in the other, the resulting shock literally threw me across the room. So, I stayed away from tubes for about two decades following ...

While I simply enjoyed the wonderful music coming from the "family" stereo — a Magnavox console with 12-inch speakers on each end, four front-mounted cone tweeters, and a heart that glowed orange — its single 6EU7 and one 6BQ5 per channel provided less than five watts of tube power, but it was adequate to the task. Using several similar tubes, this rebuild project produced around 15 watts per channel — more in line with today's less efficient speakers.

During the late 70s and into the 80s, I changed various audio components many times. Also during that period, I owned maybe half a dozen broken Dynaco Stereo-120s, which I repaired and then sold. That is, except for the one used in my "backup" mostly Dynaco, stereo system (AF-6, PAT-5, ST-120, AR-4x's).

This was used both for TV sound and as a secondary stereo system. When it came to transistors, I always loved the Dynaco Stereo-120 for its okay sound

and the simplicity of its design. Yes, folks, the minimalists are right, less is often better. Especially where transistors are concerned.

Of all the dozens of transistor amps I tried and auditioned, I always went back to the original Dynaco Stereo-120. Then, about 12 years ago, I got tubed. A Harmon-Kardon Citation I, II, and III; and then an Acrosound Ultra-Linear Stereo-120, with (EL-34s) and a PAS-3X.

Definitively, tubes have been my mainstay ever since.

### Concept, Warnings, and Construction Details

The BENDER-2pp rebuild project presented here dismembers a Dynaco Stereo-120 transistor amplifier, and turns it into a Pentode-based push-pull amplifier! The resulting unit is sort of like the SCA-35, but due to improvements in both the high voltage and filament supplies, it probably sounds even better. Great idea, and the resulting great sound from the rebuild unit is well worth the effort.

The original transistor-based unit is mostly disassembled, and most of the parts are tossed. As can be seen from Photo 2, many of the large capacitors in the Dynaco Stereo-120s — with production running from 1963 into the late 70s — are likely failing; one failure mode is when internal gas pressure builds up and the cap "vents" gas (or explodes) or, in another case, it just is sprouting "goo" or electrolyte chemicals. The caps found in Dynaco Stereo-120s were sourced from the US, Japan, Scotland, and Great Britain. While many of these caps may be failing, some parts were of much higher quality, particularly ... the power transformers.

Used as the basis for this project, the Stereo-120 chassis and cage provides this rebuild project a most professional outward appearance. The result is both distinctive and professional when completed; especially with those six tubes sticking their silvery bulbs about a half inch out of the top of the chassis.

Also, re-using this chassis, cage, power transformer, power switch, and a few miscellaneous parts

and hardware, saves a significant amount of money. Buying the chassis, transformer, and all the other parts retail is an option, but then the costs skyrocket. The existing chassis holes are re-used where possible, which also saves somewhat on labor, but most holes must be re-drilled.

Since starting this project almost six months ago, I purchased about eight Stereo-120 amps, some working, some non-working. More variation was found in the chassis cosmetic condition. These were purchased at prices ranging from \$25.00 to \$60.00, with \$40.00 being about average. I did encounter people asking \$75.00 or more, for some (claimed) working units which, with the exception of the power transformer, wasn't a necessity for this project.

My criteria for this project was three-fold:

- 1) The amp must be relatively small and lightweight.
- 2) Construction/parts used must meet minimalist criteria, and not cost a fortune (recycling where possible).
- 3) The sound must be excellent.

The basic design is to usurp or recycle the output transformers from some unused or junker tube amp or receiver which had a power output in the 20 to 35 watts per channel range. I used transformers from an old non-functional Pioneer tube receiver that cost me \$18.00 earlier last year. Obviously, if you have a Dynaco Stereo-120 lying in the closet, the additional cost will be minimal. Using a Stereo-120 costing around \$40-\$50 and recycling high-voltage, late-manu-

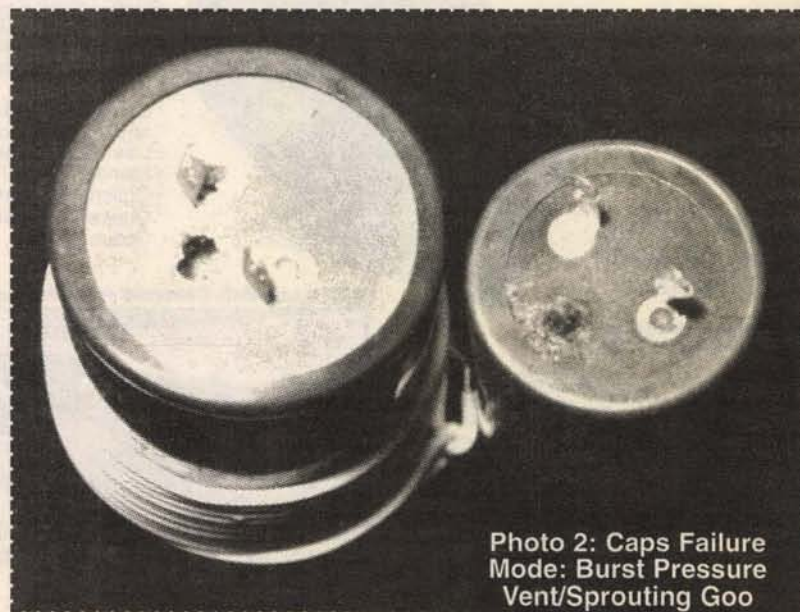


Photo 2: Caps Failure Mode: Burst Pressure Vent/Sprouting Goo

facture capacitors from disposable cameras, the total project cost can be kept to around the \$150.00 mark. Using all store-bought, first-line parts, the cost estimate goes to more than double that amount. First, before I go on, I must warn you — the assembly and construction is somewhat difficult.

## The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project



## Chart #1 Output Tube Heater Resistances

5CZ5	Heater "R" When Cold
GE Tube Sample #1 Heater Resistance:	0.96 ohms
GE Tube Sample #2 Heater Resistance:	0.96 ohms
GE Tube Sample #3 Heater Resistance:	0.97 ohms
GE Tube Sample #4 Heater Resistance:	0.94 ohms
GE Tube Sample #5 Heater Resistance:	0.94 ohms
RCA Tube Sample #6 Heater Resistance:	1.15 ohms
Average Value Total Six Samples	.987 ohms

## Chart #2 Input Tube Heater Resistances

5AN8	Heater "R" When Cold
GE Tube Sample #1 Heater Resistance:	1.08 ohms
RCA Tube Sample #2 Heater Resistance:	1.22 ohms
RCA Tube Sample #3 Heater Resistance:	1.25 ohms
RCA Tube Sample #4 Heater Resistance:	1.22 ohms
RCA Tube Sample #5 Heater Resistance:	1.21 ohms
RCA Tube Sample #6 Heater Resistance:	1.26 ohms
SYL Tube Sample #7 Heater Resistance:	1.08 ohms
SYL Tube Sample #8 Heater Resistance:	1.12 ohms
SYL Tube Sample #9 Heater Resistance:	1.05 ohms
SYL Tube Sample #10 Heater Resistance:	1.16 ohms
SYL Tube Sample #11 Heater Resistance:	1.13 ohms
SYL Tube Sample #12 Heater Resistance:	1.15 ohms
Average Value Total 12 Samples	1.16 ohms

Measurements taken with Fluke 79 Meter Lo-Ohms scale using the "CAL" function, lead resistance canceled.

To begin with, more than 30 new holes must be drilled into the HEAVY STEEL CHASSIS. Next, **the voltages present in this project can KILL!** The Cap Bank stores in excess of 50 Joules of energy, which can melt a screwdriver or kill most mammals. Proper adherence to precise construction techniques and testing procedures is mandated. If another amplifier is used as the basis for the project — *which isn't recommended* — its chassis still must be made of steel (The Harmon Kardon Citation 12 comes to mind as a possibility) for various reasons that will be explained later. Again, placement of parts is often critical, tolerances are small or zero in most cases.

I should note at this point that the internal height of the Dynaco Stereo-120 chassis is just under 3.6", so any transformers which are more than 3.5 inches in height won't fit, unless the cage is cut to allow it to stick out the top. Any output transformer of 3.625" wide x 2.5" deep x 3.5" tall, or smaller, should fit (but part of the edge of the steel cage will need to be altered for transformers which are more than 3-1/8" wide). (An alternate pair of store-bought output transformers will be discussed in Part II which are 3.75" wide. These will need further changes and accommodation.)

What goes into this project is quite constrained by the limited floor space inside the original Stereo-120 chassis, which provides a usable floor area of 11-3/4" x 9". As this is rather small by "tube" standards, it's pretty tight in there. If a Dynaco Stereo-120 isn't available, a suitable 12" x 8" x 2" steel chassis, bottom plate, and vented cage is available for about \$75.00, as cited in the alternate parts list. That chassis option provides even less floor space, but offers a five inch above chassis height capable of accommodating larger transformers, as well as a sub-chassis space for mounting parts, so it could be a working solution.

The resulting unit would be about eight inches tall, while the Dynaco chassis is just under four inches tall (not counting the rubber feet). Use of a store-bought chassis would mean also locating a suitable power transformer. In itself, that probably would cost nearly as much as the chassis/cage assembly.

As can be seen in the various photos, all circuitry is fashioned using point-to-point soldering techniques. Beyond that, the physical construction uses old-fashioned prepunched insulating perfboard to help keep

things in their place. Feel free to use higher quality caps, silver wire, etc., if it fits. I find that the resulting sound will be pretty much based on the output transformers. As a do-it-yourself project, if the output transformers are from a brand-name junker unit, I'd suggest that the best choice is a receiver or amplifier that uses similar or larger output tubes. The tube types to look for include push-pull pairs of: 6V6, 6L6, 6BQ5, 5881, 7189, 7591, or 7868s, among others.

## Filament Voltages and Some Data

Engineers are people who make choices from many possible solutions, and those choices reflect their opinions about what is necessary and what costs the least. One engineering axiom that cannot be avoided is that high-power tubes have a high quiescent heat output, resulting both from heater currents and plate dissipations (much unlike transistors, unless they are running full Class A).

So, for tubes, thermal considerations are quite important. The rebuild amplifier, as it is described herein, incorporates three small, low-voltage fans in an attempt to dissipate those many BTUs (British Thermal Units). Fans make noise but, if properly working, properly secured, and used, their intrusion into the acoustic environment is minimal.

Since the original Dynaco amplifier contained no tubes, the power transformer has no filament windings; as our rebuild project uses tubes, we must provide for our heater elements. The heater voltages provided must be close to the nominal rating for the tube, or the operating points will be off, which changes the sound.

Heater voltages should never be higher than the rated amount, as that can shorten tube life considerably. Slightly lowered heater voltages (like minus 2% or minus 3%) should increase tube life appreciably, without affecting either the sound or operating points.

Some "weird" choices have been made for this project; the first deviation is the use of tubes not having 6.3-volt heater filaments. Early on, lead-acid type storage batteries averaged in at that voltage. So, for many reasons, heater filaments mostly became 6.3 volts. That was over 75 years ago, and a project built today should have no such limitations.

For the filaments, either AC (Alternating Current) or DC (Direct Current) can be used. DC current is better. The DC version would likely include the design of a linear power supply (LPS), consisting of: a high amperage transformer; bridge rectifier, large size filter caps; zener diodes, transistors, or an IC regulator for current regulation.

Such an LPS supply could be tuned to whatever voltage or voltages you wanted, which could allow using any tube heater voltages you could want. However, the lack of physical space for an additional large transformer, and large value filter caps, etc., is a problem.

Eventually, thoughts run to a complicated power supply circuit, using multiple transistors for a capaci-

tance multiplier, and then a feedback circuit, an IC regulator, a pass transistor, etc. It gets to be a headache. It could become a bit of a squeeze to get it in, and maybe, a design nightmare.

In addition, this circuit has to be reliable running in a hot amplifier. Variations and problems in mounting an IC, and/or pass transistors to a heatsink, or to the chassis, means it could be a lot of design work and still blow itself up. In the end, such a linear supply might not fit in the available space. Also, taking into account line voltage changes and device temperature variations, unless a feedback regulated circuit is designed, it still would be messy, problematic, and possibly unstable, resulting in wide variations in amplifier performance.

The solution was simple — a switching power supply (SPS) as used in most computers. An SPS is easy to implement and needs few, if any, external parts. It is reliable, produces almost no heat, and the most modern designs are stable for line voltages varying over the range of 90-220 volts. These are pure DC and, best of all, they are small, lightweight, and already built!

The only drawback: they emit RFI interference and so this small SPS must be suitably shielded, which means a steel chassis, surrounded by metal on all sides. Finding suitable SPS units that fit the available space inside the Dynaco Stereo-120 chassis is not easy, but several choices are available.

When choosing an SPS, one must take into account both the output voltages and the current capacity. Some SPS units have a single output voltage. Others have two or more. The design of the typical SPS supply is for higher current from the +5-volt line and lesser current from the 12-volt line, the -12-volt line, etc. To avoid the SPS from behaving erratically, the load must be present and balanced relative to each output line's limits. The original amp design had a load that was the exact reverse of the typical SPS load situation: loading the five-volt line lightly and the 12-volt line more heavily. That led to a re-evaluation and change in the tubes used in this project.

The actual measured voltages under load tell the story of how the SPS is performing. Under the load used, the outputs of the supply should stay within one or two percent of the nominal voltage (which is the voltage when loaded with rated load — as all SPS must be tested

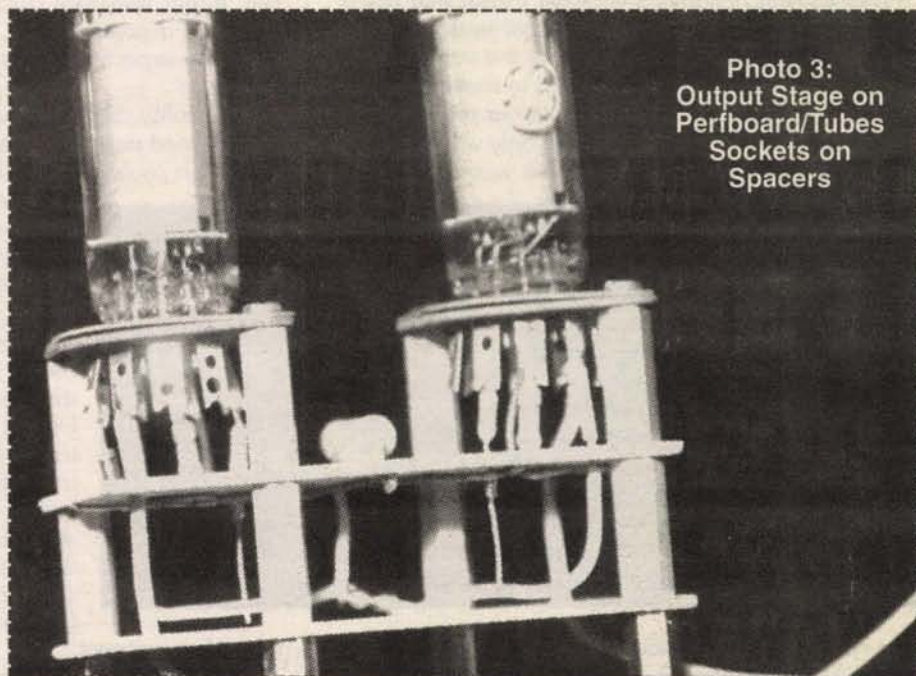


Photo 3:  
Output Stage on  
Perfboard/Tubes  
Sockets on  
Spacers

under load). The nominal heater load of the 5AN8 and 5CZ5 tubes is 4.7 volts @ 600 mA each. I ran some tests on each of these tubes when "cold" (an out-of-the-circuit condition), as shown in Charts 1 and 2.

## Problems, Problems, and More Problems

**Problem #1.** Smaller SPS supplies are designed



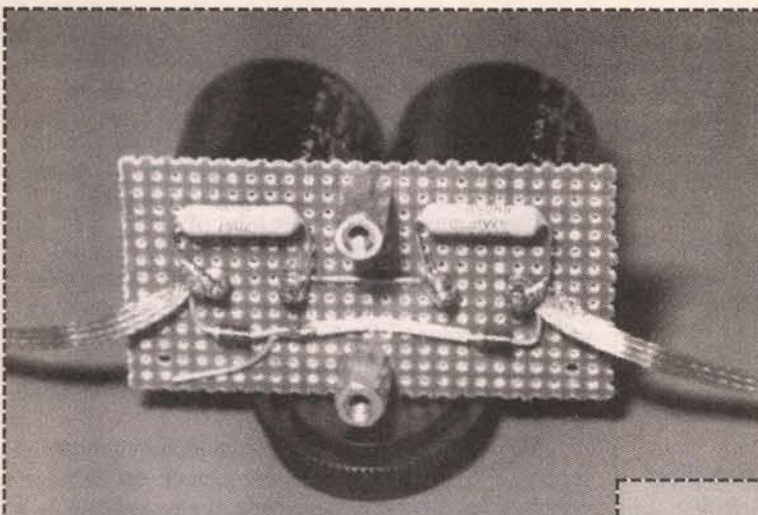


Photo 4: Bottom View: High-Voltage Supply Board

for a constant load. That means under start-up conditions, the load seen cannot exceed the nominal load by more than 50%. While the nominally 4.7 volt/600 mA filaments have an effective resistance of 7.83 ohms when operating (as can be seen from the graph), when "cold" they can be as low as 0.94 ohms. This represents a variation of cold to hot exceeding 800% (actually 8.3:1) during the first 15 seconds or so, while the heaters heat up.

Even if the nominal value of the heater resistance is acceptable when hot, it is nearly a short circuit when cold. When you parallel two, three, or six of such tube filaments as required by the circuit, you get some very low-resistance values, making it literally impossible to drive with an SPS supply.

One amplifier channel represents a 5AN8 and a pair of 5CZ5s with the three filaments in parallel. Now, ignoring cable resistance and socket contact resistances, this would present a nominal value of 0.35 ohm load to the SPS upon start-up. This represents ( $V = I \cdot R$  or  $5.1 = I \cdot 0.35$ ) or 14.7 amps of start-up current, while the nominal operating current is 1.8 amps. That means an unreliable start-up situation. Sum both channels together and it gets even worse: a start-up current of 29.5 amps.

The problem is the SPS protection circuit. All SPS designs incorporate a Crowbar Circuit that reacts to a shorted output line. The results of resistance tests pretty much ruled out using multiple five-volt tubes with an SPS, unless they were used in multiples of four, or maybe series connected, but our resistances varied and series connection would only work if the output voltage was 15 volts, and that would divide up

and expensive) or make use of a DC-to-DC converter, which would take the five volts and convert it to nine volts or 12 volts (but these are expensive, too).

A few SPS units found that meet the physical criteria for our Dynaco chassis also meet the basic current draw for our five-volt tubes. As the load presented by the input tubes would load the five-volt line at 1.8 amps (per channel), we needed either two SPS units of about 2-amp capability, or one that could handle 3.6 amps without problems, with the output voltage within one percent of their nominal values, and DC ripple that was still negligible.

in the range of 1.8 amps. On the prototype, the heater voltages stabilized at around 4.60 volts.

## Alternative Filament Supplies

As it turns out, several choices of switching power supplies are available to meet the power and size requirements to fit the available space in our Dynaco chassis. Switching power supplies having nominal ratings from 25 watts to 40 watts are the available range of the tube heater variations. A 3.5-ohm thermistor in series with the set of three paralleled tube heaters, presents a load of 3.85 ohms to the SPS when the filaments are cold (that's 1.3 amps). When the thermistor heats up, it takes itself partially out of the circuit, reducing the voltage to around 4.6 volts at the tubes,

which is within two percent of the nominal 4.7-volt heater rating. This was used to produce a workable, reproducible, and reliable solution.

After 30 seconds, the three paralleled heaters have approached their nominal resistance, and their load is about 2.6 ohms and the current is about 1.8 amps. Since the resistance value of the thermistor varies with its current and temperature, it is effectively in the circuit at room temperature, later dropping down to ~.50 volts (about .3 ohms) when it warms up (from several manufacturers). Using two 5CZ5s and a 5AN8 per channel, one workable example is Pihong's PSA-25-105; with dimensions of 4" x 3" x 1.3", it is a single output, 25 watt model giving five volts at five amps,

costing \$32.60 (quantity one). One of these would work fine for all of our heater filaments.

Another possibility is Pihong's multiple output unit model PSA-25-301. This SPS gives 5 volts @ 2 amps, 12 volts @ 1.0 amp and -12 volts @ 0.3 amp. I'm sure that using either pair of these would work, as it also provides for the 12-volt fans without additional problems. The presence of the -12 volt line might also be of benefit, to supply the appropriate bias voltage, without needing to make the separate Minus Bias Supply. These SPS also cost: \$32.60 each, and two would be required.

Two other possibilities from Cosel are one each of their LCA15S-5 for 5 volts/3 amps, and a LCA15S-12 12 volts/0.9 amp for powering the fans. They are rated at only 15 watts each, cost \$30.39 each, but could be used — considering the fan cooling factor — as we really do need 5 volts at 3.6 amps.

Another PS from Condor DC Power Supplies is their Model GPC41-5 — a single output five volt/unit rated at 40 watts (5V/8A), measuring a compact 4" x 2" x 1.46", costing \$50.00. Condor also has a DC-DC converter, model ZS-30512, that takes five volts and gives out 12 volts at .25 amp, which should be enough to power three small fans. That DC-DC converter costs \$23.85.

Initially, testing of a single channel prototype amplifier was performed using a 30-watt SPS on the filaments. The voltages remained stable without measurable change for several hours at a time. The measured filament voltage did not change (at all) while varying the applied line voltage from 123.6 volts down to under 65 volts. Residual AC ripple was well under 100 mV on the tube filament pins. Using a variac, once the AC line was cranked up beyond 90 volts and the SPS was operating, the AC Line could then be lowered down to 59 volts before a change in the heater output voltages was detected. At a 56-volt AC line, the heaters dropped down to 4.50 volts, the -5 percent point. At 54.4 volts, the heaters went down to 4.40 volts (-6 percent) and, at 52.2 volts it became 4 volts (-10 percent). Try that test with any transformer or linear regulated supply. It would probably have dropped down to somewhere around 2.5 volts under those voltage conditions.

**Problem #2.** Some physically small 25/30/40 watt SPS supplies that were located might work under normal load conditions, but start-up currents made for an unstable problem. The dual voltage supplies could produce more output from the five-volt line than their rated current, as long as the second output line was lightly loaded or unloaded. This sharing is not a problem; as long as the output voltage remains within, say, two percent of the nominal.

The second consideration was the temperature of the SPS heatsink and the small transformer in the circuit. If they remained close to room temperature, or below 50 degrees Celsius, no problems or failures would be expected. Forced air cooling (a fan) helps in this area.

In reality, SPS supplies are most efficient when loaded/used near their maximum output capabilities, where fan cooling can extend the range. More serious was the turn-on problem. This was solved rather ingeniously, using a negative temperature coefficient thermistor, which operates in the almost opposite way.

In-circuit temperature measurements (in degrees Celsius) of the thermistor can be seen in Chart 3. During the tube warm-up time — the first 11 seconds — the thermistor increases from room temperature to 53 degrees centigrade. It approached its maximum of 76.5 degrees Celsius after two hours — about one-half of the 150 degree Celsius-rated maximum for this

type of component.

Upon turn-off, the thermistor dropped back to near room temperature within about two minutes. The other added benefit here, is this provides a "soft" start-up and a lack of "flash" for thermally volatile heater elements, insuring prolonged tube heater life.

Within 30 seconds of turn-on, when the combined three tube heaters resistance has risen to the nominal 2.6 ohms, the thermistor has increased its temperature to over 60 degrees Celsius, and its resistance dropped to under 0.3 ohms (~0.5 volt drop) when conducting

## Chart #3 Thermistor Temperature over Time

Time = 0 seconds = Pwr On	Temperature = 27.3 degrees C
Time = 11 seconds	Temperature = 53.0 degrees C
Time = 1 minute	Temperature = 67.0 degrees C
Time = 30 minutes	Temperature = 73.9 degrees C
Time = 120 minutes	Temperature = 76.5 degrees C

Above Using Fluke Model 52 Digital Temperature Meter

unevenly, as the resistances were not the same, even though the theoretical operating currents were the same.

We could use the five-volt line, which is the primary reference and even leave the 12-volt line unused (on those SPS that have a 12-volt line). The 12-volt line could readily be used for the small fans to be placed in the chassis, which was an advantage, as more fans are designed for 12 volts than for five volts.

Using a five-volt only SPS supply, one would have to use either five-volt fans (which are hard to locate

## The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project



## Choosing Tube Sets

The aforementioned 5CZ5 Pentode has a 12-watt rated maximum plate dissipation, and it is readily available (at least in the near term), priced around \$5-\$8 apiece. Two possible alternates (but not pin-for-pin substitutes) are, the 10BQ5 and 10CW5 (using 10.6 volt filaments).

In that case, the bias levels, pin connections, and the filament power supplies would all have to be changed. It's quite probable that most multiple 5V/12V output SPS units (like Phihong's PSA-25-301), could readily be adapted to these alternate tube sets.

A 5AN8/10BQ5 system would require 5 volts @ 0.6 amp, and 10.6 volts @ 0.9 amp per channel — well within the PSA-25-301's ratings. The 12-volt line voltage could be dropped using an NPC thermistor and maybe, if needed, a series 1N4005 diode in series with each tube heater.

I'm sure that using either a pair of these SPS would work, and it also provides for the 12-volt fans without additional problems. On that particular SPS, the -12 volt line might be able to supply the appropriate bias, without needing to make the separate minus bias supply, as the bias voltage on the 10BQ5 is less negative than either the 5CZ5 or 10CW5 tubes.

The other noted possible alternative is the 10CW5; it has a lesser maximum plate voltage rating, which isn't a problem in this circuit or instance. Getting vastly different, 8BQ5s can probably be adapted to this design, if the SPS used can provide the proper filament voltage and current. But, again, such a substitution is only a possible option, left to the builder to make it work; configurations using the 10CW5, 10BQ5, and 8BQ5 were not actually tested in this case.

## Details on the Amp's Power Supply

The original Dynaco Stereo-120's power transformer was a superb unit, but its single 70 VAC secondary voltage (when converted to DC) was around 99 volts; too low for powering tube circuitry, even using a voltage doubler. Using a voltage tripler, it would perhaps still err a bit on the low side, for even a low power tube amp. So, the solution was to rewire the primary windings, which consisted of two separate 120-volt windings tied together for 120 volts (parallel @ 3 amps) or in series (230 volts @ 1.5 amps) into isolation mode where it operates as an isolation transformer.

As quality transformers have at least 1,500 volts of isolation between windings (I tested it at over 2,000 megohms), using a transformer in this manner is perfectly acceptable, providing it does not overheat.

The original Dynaco amp originally pulled over 400 watts from the original configuration of paralleled dual primaries. Indications are that the transformer used was quite conservatively oversized to begin with. Suffice it to say, that transformer almost never gets hot under working conditions. An interesting experience was when I was testing another prototype, also based on a Dynaco Stereo-120. Following a one-third power FTC pre-test, followed by the full output power, the chassis became quite hot. In fact, three of the four rubber feet melted, but the power transformer remained cool.



Photo 5:  
Front View  
Completed  
Rebuild  
Chassis

Okay, the point of that story is that the power transformer never got hot, even under that type of extended punishment. So, this particular transformer was probably rated for 600 watts. That translates to mean it will stay cool and reliable, yet functional for the task at hand.

Since the BENDER-2pp re-design uses the SPS circuit to power the heaters, the Dynaco transformer need only supply the current to charge the high voltage caps. They, in turn, supply the needed maximum of around 200 mA per channel at 270 volts nominal. This translates to about 50 watts per channel, or 100 watts maximum (half that on average). So even with the primary windings "split" as used in this "unusual" way, the transformer is still likely good for close to 200 watts, so, it is actually being de-rated again, by about 50 percent, in this re-design.

## Fuses, Fuses, Everywhere, and Why We Have Fuses

The number of fuses present in this rebuild will vary. Some of the mentioned SPS units have their own fuse, other units lack them. The primary line fuse and the in-line fuses on the transformer's high-voltage line means a minimum of three fuses present in this design. Various fuses are designed to blow under different conditions since specific fuses are designed for different overloads.

In the primary AC input circuit, we need a 3AB ceramic slow-blow or 3AG glass slow-blow fuse. Since

mentioned.

I'd like to think a fuse would blow only in the extreme case. If a tube shorts, or the bias changes drastically, and suddenly one amp of current starts to flow in the high-voltage circuit; yes, that fuse will blow. In the case of the 3AG or 8AG fast-blow, in five seconds or less — probably less. My criteria is, under other than catastrophic failure-conditions, even tubes running at 300% of expected current (and possibly glowing red), I'd want that fuse to hold (but then the cathode resistor might fail/open). If the user wants to use a fuse rated at 250 mA (1/4 amp) here, that provides more protection, but it might fail under normal use conditions, which is annoying, problematic, and for the user, disconcerting (and the music stops, too). See Chart 4.

## The Primary High-Voltage Power Supply

The new configuration places one primary pair as the secondary into a conventional full-wave voltage doubler using a pair of 1A/600 volt diodes. Fast recovery diodes are preferred, but I used 1N4006s without any problems.

As seen in the photos, the high-voltage supply is assembled on a perfboard assembly using two 470 uF/250 volt electrolytic caps on top, and 1N4006 or 1N4937 (fast recovery) diodes along with some 300K ohm, one-watt or two-watt bleeder resistors on the bottom. This produces a no-load voltage of 344 volts

across both primary supply capacitors with no tubes or load on that circuit. With the normal set of tubes plugged in, circuit capacitor voltages never reached higher levels than 334 volts, and this is resistively dropped using two 150-ohm/15-watt chassis mount series resistors and the 2-watt/300K bleeder resistors, for a B+ of around 300 volts, using a normal complement of tubes.

The chassis mounted resistors can be seen on the heatsink

assembly in one of the photos. The 150-ohm resistors go between the primary caps of the voltage doubler and the CAP Bank, which will be discussed in Part 2.

Also in Part 2, I will provide the complete unit schematics, CAP bank details, some tube and design variations, functional and distortion tests, and tests comparing use of the Pioneer "junkie" output transformers against the store-bought Hammond Model 1620s (with and without using the ultra linear taps). NV

Chart #4 Fuses Response to Overload vs. Time

FUSE TYPE	100%	110%	135%	200% Rated Current
3AB Ceramic Slow-Blow	Indef	4 hr. min	1 hr. max	5 sec. minimum
3AG Glass Slow-Blow	Indef	4 hr. min	1 hr. max	5 sec. minimum
3AG Glass Fast-Blow	Indef	4 hr. min	1 hr. max	5 sec. maximum
8AG Normal-Blow	Indef	4 hr. min	1 hr. max	10 sec. maximum
8AG Fast-Acting	4 hr. min	-N.R.-	-N.R.-	5 sec. maximum

N.R. - Not Rated.

the actual power consumption is constant at around 75 watts (~.625 amp), the value for the primary fuse could be set at 1.0 or 1.5 amps, but I suspect that the combined SPS and power transformer high voltage surge would likely blow such a fuse after a while. Therefore, a better value would be 2.0 amps in that part of the circuit. So, in all probability, it would be best to replace the original Dynaco 3.0-amp slo-blow fuse with a fast blow 2.0-amp unit.

## The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project



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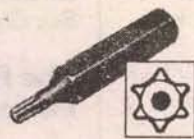
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# Events CALENDAR

Continued from page 74

116 (Barrett Pkwy) W. 1.5 mi., right on Cobb Pkwy. 1/4 mi., show on right. GA Mountain Productions 706-838-4827  
**NC - WINSTON-SALEM** - Computer Show. Lawrence Joel Veterans Memorial. 9:30am-4pm. MarketPro 201-825-2229  
**NJ - SECAUCUS** - Computer Show. Meadowlands Expo. Center. 9:30am-4pm. MarketPro 201-825-2229  
**TN - NASHVILLE** - Computer Fair. State Fairgrounds. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378

## APRIL 13

**CT - SOUTHTON** - Electronic Flea Market. Southington High School. 9am-1pm Chet 860-628-9346  
**NC - RALEIGH** - NCARS 25th Hamfest & Computer Fair. Jim Graham Bldg., NCS Fairgrounds. 8am-4pm. Ronnie Reams 919-217-0263  
**NY - ROCHESTER** - Computer Show. The Dome Center. 9:30am-4pm. MarketPro 201-825-2229  
**OH - CIRCLEVILLE** - Hamfest/Computer Show. Pickaway Co. Fairgrounds Coliseum. Roy Ulko 614-477-8310  
**PA - BLOOMSBURG** - ARRL Hamfest. Dave Schack 717-752-6851  
**WI - MADISON** - Swapfest. Dan Co. Expo Center Exhibition Hall. MARA 608-245-8890

## APRIL 18-19-20

**IL - QUAD CITY** - Computer Show. QCCA Expo Center. Blue Star Productions 612-788-1901

## APRIL 19

**CANADA - ONTARIO - PICKERING** - Hamfest. Ian Smith 905-427-4873  
**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052  
**MO - JOPLIN** - ARRL Hamfest. Joplin ARC. Andy Gabbert 417-673-8371  
**NH - NASHUA** - Electronic Fleamart. Res. Ctr. Church. 617-923-2665

## APRIL 19-20

**KY - LOUISVILLE** - Computer Fair. KY Fair & Expo Center. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378

**NY - STONY BROOK** - Computer Show. SUNY Stony Brook. 9:30am-4pm. MarketPro 201-825-2229

## APRIL 20

**CT - HARTFORD** - Robotics Contest. Trinity College. Jake Mendelsohn 860-233-2379  
**DE - NEW CASTLE** - State Convention. Hal Frantz 610-485-4844  
**MA - CAMBRIDGE** - Hamfest. MIT RS & Harvard Wireless Club. Nick Altemburnd 617-253-3776

## APRIL 25-26

**AR - LITTLE ROCK** - ARRL Hamfest. Jim Blackmon 501-246-7833

**NE - SOUTH SIOUX CITY** - Iowa State Convention. Mike Nickolaus 402-494-6070

## APRIL 25-26-27

**MN - ST. PAUL** - Computer Show. State Fair Grounds. Blue Star Productions 612-788-1901

## APRIL 26

**CO - DENVER** - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664

**NJ - BELVIDERE** - ARRL Hamfest. Charlie Kosman 908-788-4080

**OR - ROSEBURG** - ARRL Hamfest. Ed Pahl 541-673-1310

## APRIL 26-27

**FL - SARASOTA** - Computer Show. Municipal Auditorium. Frank Cox 941-954-0202

**NC - CHARLOTTE** - Computer Show. Charlotte Merchandise Mart. 9:30am-4pm. MarketPro 201-825-2229

**NY - WHITE PLAINS** - Computer Show. Westchester Co. Center. 9:30am-4pm. MarketPro 201-825-2229

## APRIL 27

**IL - ARTHUR** - ARRL Hamfest. Moultrie ARK. Ralph Zancha 217-873-5287

**IL - GLEN ELLYN** - Computer Show & Sale. College of DuPage. Main Arena of Phys Ed Bldg. Corner of Park Blvd. & College Rd. 9:30am-3pm. Computer Central Shows 847-940-7547

**NY - Poughkeepsie** - ARRL Hamfest. Mt. Beacon ARC. Ken Akasofu 914-485-9617

**OH - ATHENS** - ARRL Hamfest. Athens Co. ARA. John Cornwell 614-593-6474

## MAY 1997

### MAY 2-3-4

**WI - WAUSAU** - Computer Show. Wausau/Marathon Co. Park. Blue Star Productions 612-788-1901

### MAY 3

**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 317-299-8827

317-299-8827

## MAY 4

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

**NY - YONKERS** - Electronic Flea Market. Lincoln High School. Otto 914-969-1053

## MAY 9-10-11

**IA - DES MOINES** - Computer Show. State Fairgrounds. Blue Star Productions 612-788-1901

## MAY 10-11

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## MAY 17

**NY - BUFFALO** - Computer Show. Hamburg Fairgrounds. 9:30am-4pm. MarketPro 201-825-2229.

## MAY 18

**NY - ROCHESTER** - Computer Show. The Dome Center. 9:30am-4pm. MarketPro 201-825-2229.

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## MAY 26

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## MAY 30-31-JUNE 1

**NY - ROCHESTER** - Atlantic Conv. Harold 716-424-7184

## MAY 31

**CO - DENVER** - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664

## JUNE 1997

### JUNE 1

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

### JUNE 14-15

**GA - KENNESAW** - Computer Show. I-75 to Exit 116 (Barrett Pkwy) W. 1.5 mi., right on Cobb Pkwy. 1/4 mi., show on right. GA Mountain Productions 706-838-4827

### JUNE 21

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### JUNE 28

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### JUNE 29

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## JULY 1997

### JULY 12-13

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### JULY 19

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### JULY 26

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Charles Walsh and his students in Great Falls, Montana, use BASIC Stamps in robotics projects.



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Although it may be difficult to see here, that's a BS1-IC, next to the white wires.

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